Canada's Nuclear Regulator

Reactor Facilities

Site Evaluation and Site Preparation for New Reactor Facilities

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Site Evaluation and Site Preparation for New Reactor Facilities
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Preface

This regulatory document is part of the CNSC's reactor facilities series of regulatory documents, which also includes licence application guides for licences to construct, operate and decommission nuclear power plants. The full list of regulatory document series is included at the end of this document and can also be found on the CNSC's website.

Regulatory document REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities* sets out requirements and guidance for site evaluation and site preparation for new reactor facilities. It also includes a licence application guide for a licence to prepare a site for new reactor facilities. This document refers to both nuclear power plants and small reactor facilities as "reactor facilities". Its content also addresses how site evaluation information obtained during site preparation activities is used and revisited in subsequent lifecycle phases of construction and operation.

This regulatory document replaces the previously published RD-346, *Site Evaluation for Nuclear Power Plants*. It revised RD-346 to:

- expand scope to include small reactor facilities using a graded approach
- include site preparation requirements and guidance
- describe the necessary robust characterization of the site to include:
  - consideration of events to include multiple and simultaneous severe external events that could exceed the design basis
  - multiple and simultaneous reactor accidents
  - discussions around emergency planning and preparations for extreme events earlier in a project

This document will be used to assess licence applications for new reactor facilities (including as support information for the construction and operational phases) and should be considered as a modern standard that should be included in a periodic safety review (PSR) for existing reactor facilities. Once the Commission has granted a licence to prepare site, the safety and control measures described in the licence application and the documents needed to support the application will form part of the licensing basis.

Guidance contained in this document exists to inform the applicant, to elaborate further on requirements or to provide direction to licensees and applicants on how to meet requirements. It also provides more information about how CNSC staff evaluate specific problems or data during their review of licence applications. Licensees are expected to review and consider guidance; should they choose not to follow it, they should explain how their chosen alternate approach meets regulatory requirements.

A graded approach, commensurate with risk, may be defined and used when applying the requirements and guidance contained in this regulatory document. The use of a graded approach is not a relaxation of requirements. With a graded approach, the application of requirements is commensurate with the risks and particular characteristics of the facility or activity.

An applicant or licensee may put forward a case to demonstrate that the intent of a requirement is addressed by other means and demonstrated with supportable evidence.

The requirements and guidance in this document are consistent with modern national and international practices addressing issues and elements that control and enhance nuclear safety. In particular, they establish a modern, risk-informed approach to site evaluation.

By following the information in this regulatory document, applicants will submit the appropriate information to demonstrate that they are qualified and will make adequate and reasonable provisions to undertake the activity to be licensed.

Version 1.2 includes administrative updates to reflect the latest changes made to the CNSC's Safety and Control Area Framework

Important note: Where referenced in a licence either directly or indirectly (such as through licensee-referenced documents), this document is part of the licensing basis for a regulated facility or activity.

The licensing basis sets the boundary conditions for acceptable performance at a regulated facility or activity, and establishes the basis for the CNSC's compliance program for that regulated facility or activity.

Where this document is part of the licensing basis, the word "shall" is used to express a requirement to be satisfied by the licensee or licence applicant. "Should" is used to express guidance or that which is advised. "May" is used to express an option or that which is advised or permissible within the limits of this regulatory document. "Can" is used to express possibility or capability.

Nothing contained in this document is to be construed as relieving any licensee from any other pertinent requirements. It is the licensee's responsibility to identify and comply with all applicable regulations and licence conditions.

Table of Contents

Site Evaluation and Site Preparation for New Reactor Facilities

1. Introduction

1.1 Purpose

This regulatory document provides requirements and guidance for site evaluation and site preparation for new reactor facilities. It also includes a licence application guide for a licence to prepare a site for new reactor facilities.

Site evaluation is integral to applications for licences to prepare a site to construct a nuclear facility, to operate and to decommission. The site characterization information obtained during site evaluation is taken into account in the design of the reactor facility and reevaluated during site preparation and over the lifecycle of the reactor facility (that is, construction, operation and decommissioning), including the periodic safety reviews and updates to the environmental risk assessment.

1.2 Scope

This document refers to both nuclear power plants and small reactor facilities as "reactor facilities". All criteria in this document can be applied to a smaller reactor facility using a risk-informed approach.

This document does not address site evaluation or site preparation for Class IA and IB nuclear facilities other than nuclear power plants and small reactor facilities.

Further explanation on the application of site evaluation information in all lifecycle phases is provided in section 2, Background.

1.3 Relevant legislation

The following provisions of the *Nuclear Safety and Control Act* (NSCA) and the regulations made under it are relevant to this document:

- subsection 44(1) of the NSCA states that "The Commission may, with approval of the Governor in Council, make regulations
  […]
  (e) respecting the location, design, construction, installation, operation, maintenance, modification, decommissioning, abandonment and disposal of a nuclear facility or part of a nuclear facility;
  […]
  (o) establishing requirements to be complied with by any person who possesses, uses, packages, transports, stores or disposes of a nuclear substance or prescribed equipment or who locates, designs, constructs, installs, operates, maintains, modifies, decommissions or abandons a nuclear facility or nuclear powered vehicle;"
- section 3 of the *Class I Nuclear Facilities Regulations* states that "An application for a licence in respect of a Class I nuclear facility, other than a licence to abandon, shall contain the following information in addition to the information required by section 3 of the *General Nuclear Safety and Control Regulations*:
  (a) a description of the site of the activity to be licensed, including the location of any exclusion zone and any structures within that zone;

(b) plans showing the location, perimeter, areas, structures and systems of the nuclear facility;
(c) evidence that the applicant is the owner of the site or has authority from the owner of the site to carry on the activity to be licensed;
(d) the proposed management system for the activity to be licensed, including measures to promote and support safety culture;
(d.1) the proposed human performance program for the activity to be licensed, including measures to ensure workers' fitness for duty;
(e) the name, form, characteristics and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on;
(f) the proposed worker health and safety policies and procedures;
(g) the proposed environmental protection policies and procedures;
(h) the proposed effluent and environmental monitoring programs;
(i) if the application is in respect of a nuclear facility referred to in paragraph 2(b) of the *Nuclear Security Regulations*, the information required by section 3 of those Regulations;
(j) the proposed program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed; and
(k) the proposed plan for the decommissioning of the nuclear facility or of the site."

- section 4 of the *Class I Nuclear Facilities Regulations* states that "An application for a licence to prepare a site for a Class I nuclear facility shall contain the following information in addition to the information required by section 3:
(a) a description of the site evaluation process and of the investigations and preparatory work that have been and will be done on the site and in the surrounding area;
(b) a description of the site's susceptibility to human activity and natural phenomena, including seismic events, tornadoes and floods;
(c) the proposed program to determine the environmental baseline characteristics of the site and the surrounding area;
(d) the proposed quality assurance program for the design of the nuclear facility; and
(e) the effects on the environment and the health and safety of persons that may result from the activity to be licensed, and the measures that will be taken to prevent or mitigate those effects."

- section 5 of the *Class I Nuclear Facilities Regulations* states that: "An application for a licence to construct a Class I nuclear facility shall contain the following information in addition to the information required by section 3:
(a) a description of the proposed design of the nuclear facility, including the manner in which the physical and environmental characteristics of the site are taken into account in the design;
(b) a description of the environmental baseline characteristics of the site and the surrounding area;
[…]
(i) the effects on the environment and the health and safety of persons that may result from the construction, operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects;
(j) the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics;
[…]"

- section 6 of the *Class I Nuclear Facilities Regulations* states that: "An application for a licence to operate a Class I nuclear facility shall contain the following information in addition to the information required by section 3:
  […]
  (h) the effects on the environment and the health and safety of persons that may result from the operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects;
  (i) the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics;
  […]"

- section 7 of the *Class I Nuclear Facilities Regulations* states that: "An application for a licence to decommission a Class I nuclear facility shall contain the following information in addition to the information required by section 3:
  […]
  (b) the nuclear substances, hazardous substances, land, buildings, structures, systems and equipment that will be affected by the decommissioning;
  […]
  (e) the nature and extent of any radioactive contamination at the nuclear facility;
  (f) the effects on the environment and the health and safety of persons that may result from the decommissioning, and the measures that will be taken to prevent or mitigate those effects;
  (g) the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics;
  (h) the proposed measures to control releases of nuclear substances and hazardous substances into the environment;
  (i) the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security, including an emergency response plan;
  […]"

Federal environmental assessment legislation applies in the following instances:

- designated projects
- projects proposed to be carried out on federal lands

1.4 National and international standards

Key principles and elements used in developing this document are consistent with national and international standards.

Some sections of this document represent the CNSC's adoption of the site evaluation principles set forth by the International Atomic Energy Agency (IAEA) in NS-R-3 (Rev 1), *Site Evaluation for Nuclear Installations* [1] and the IAEA guides that support it. Where necessary, the tenets have been adapted to make them applicable to the CNSC's regulatory requirements. The scope of this document goes beyond NS-R-3 in several aspects, such as protection of the environment, security of the site and protection of prescribed information, which are not addressed in NS-R-3.

This document serves the broader licensing needs under the NSCA and provides additional guidance for facilitating a more effective and efficient regulatory review. As with NS-R-3, this document considers all licensing phases, because information from the site evaluation process is required to support the CNSC licensing process at all phases of the facility lifecycle.

2. Background

Under the *Nuclear Safety and Control Act* (NSCA), the CNSC does not licence a reactor design. The following activities may be licensed:

- site preparation for the purpose of constructing or operating a reactor facility
- construction of a reactor facility
- operation of a reactor facility
- decommissioning of a reactor facility
- abandonment of a reactor facility

Licences can be combined to permit multiple activities. The applicant shall address all regulatory requirements pertaining to all activities proposed in the licence application.

In most cases, policies, programs, processes, procedures and other safety and control measures developed at the lifecycle phase of site preparation will continue to be used, and will be adapted to support future phases of the project (that is, facility construction and operation).

Where language is used, such as "current licensing phase" or "activities being conducted under the current licence", the reader should interpret the text in the literal sense, but also from the point of view of an applicant seeking a decision from the Commission to conduct activities under that licensing phase. For example, if the current licensing phase is the licence to prepare site, requirements and guidance refers to either an applicant seeking a decision on an application for a licence to prepare site, or to a licensee conducting activities under a licence to prepare site.

Early in the site evaluation process, the applicant shall conduct a review to consider whether the activity described in their licence application requesting authorization from the Commission:

- could affect the environment
- could adversely affect an Aboriginal group's potential or established Aboriginal and/or treaty rights, such as the ability to hunt, trap, fish, gather or conduct cultural ceremonies

If the review identifies effects, the applicant shall submit their review to the CNSC as part of their licence application or as a project description if decision on an environmental assessment (EA) under federal environmental assessment legislation is being sought prior to a licensing decision.

Proposed projects may raise the Crown's duty to consult. While the CNSC cannot delegate its obligation, it can delegate procedural aspects of the consultation process to applicants and licensees. The information collected and measures proposed by applicants and licensees to avoid, mitigate or offset adverse effects may be used by the CNSC in meeting its consultation obligations.

2.1 Environmental assessments

For EAs conducted by the CNSC in accordance with federal environmental assessment legislation, the Commission must render an EA decision prior to making a licensing decision under the NSCA.

Site evaluation comprises a substantial part of an EA conducted in accordance with federal environmental assessment legislation. As such, information gathered during the site evaluation process should be used during the EA process. This information will be reviewed by the CNSC during the assessment of all licence applications in the facility's lifecycle, in particular for preparing the application for a licence to prepare site.

For more information on the CNSC's EA and licensing processes, see:

- REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2]
- REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, Version 2 [3]

2.2 Public and Aboriginal engagement

Due to the nature of site evaluation and site preparation, public and Aboriginal engagement is a significant aspect of these stages.

By addressing requirements early in the site evaluation and site preparation stages, public consultation and Aboriginal engagement are expected to lead to more effective and efficient consultation practices, strengthen relationships with Aboriginal communities, assist the CNSC in meeting its obligations regarding its duty to consult, and reduce the risk of delays in the regulatory review processes.

2.2.1 Public information and disclosure

Early in the site evaluation process, the applicant shall develop and implement a public information and disclosure program and, as part of the application for a licence to prepare the site, submit the program to the CNSC.

For more information, see RD/GD-99.3, *Public Information and Disclosure* [4].

2.2.2 Aboriginal engagement

When the applicant determines that the activity described in their licence application requesting authorization from the Commission could adversely affect potential or established Aboriginal and/or treaty rights, they shall:

- identify and engage with potentially affected Aboriginal groups
- submit an Aboriginal engagement report
- submit material change updates to the Aboriginal engagement report
- include a summary of Aboriginal engagement activities in their licence application and any submissions to the Commission

For more information, see REGDOC-3.2.2, *Aboriginal Engagement* [5].

2.3 Overview of site evaluation

Site evaluation is done before the applicant submits an application to prepare a site for the eventual construction of a reactor facility. During the lifecycle of the nuclear facility, the site evaluation is reviewed and updated to reflect changes in the vicinity of the site, or to incorporate new scientific data and knowledge.

Information from the site evaluation should be continually considered throughout the lifecycle of the proposed facility (including construction and operation), to ensure that the facility's design basis and safety case remain current with changing environmental conditions or modifications to the facility itself. A brief summary of the application of site evaluation information to the facility lifecycle phases is provided below:

- **site evaluation:** section 3 of this document describes the information gathering and initial submission activities for the proposed site
- **site preparation:** section 4 describes the information to be submitted as part of a licence application for a licence to prepare the site (no work may proceed before a licence to prepare the site is approved)
- **construction:** the results of the site evaluation and, in particular, the site characterization are considered in the facility design and supporting safety analysis, which are in turn assessed as part of the review of a construction licence application
- **operation:** the site evaluation information is considered in the design and licensing basis, and carried through to the subsequent lifecycle phases, including the licence to operate; information gathered during site evaluation, including the assumptions and bounding envelope would be reconfirmed at the continuing operation phase (the information about site evaluation in this document would also be considered as part of the suite of modern codes and standards during a periodic safety review)
- **decommissioning and abandonment:** the site evaluation information is useful for the development of early strategies and plans to support the eventual dismantling of the facility and the management of waste, and to establish appropriate financial guarantees

Appendices B through G contain working-level requirements and guidance for site evaluation.

2.4 Overview of site preparation

Section 4 describes the requirements and guidance for the safety and control areas, and other matters of regulatory interest, that are applicable to site preparation.

The licensing of reactor facilities in Canada involves several steps, beginning with consideration of the proposed site, conduct of the environmental assessment and issuance of a licence to prepare site. The Commission's granting of the licence to prepare site declares the site suitable and permits the licensee to perform the licensed activity (site preparation). **Note:** No licence will be issued until the EA is complete and the Commission has determined that the proposed project is not likely to result in adverse environmental effects, taking into consideration the implementation of mitigation measures. For more information on the CNSC's EA and licensing processes, see:

- REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2]
- REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, Version 2 [3].

A substantial part of the submissions for the application for a licence to prepare site is used to demonstrate that the proposed site will also be suitable for the construction and operation of the proposed facility.

The site characterization and environmental assessment determine, for the entire lifecycle of the project, whether:

- siting option choices were made to avoid or minimize environmental effects
- the proposed facility and site infrastructure designs to be established are adequate (including the exclusion zone boundary, where appropriate)
- the applicant will ensure adequate provision for the protection of the environment, the health and safety of persons and maintaining national security
- effects are likely significant, taking into consideration mitigation measures

Significant site evaluation work should be completed before initiating the application for a licence to prepare site. The CNSC recommends the applicant use the pre-application period to develop the safety case for site preparation, along with supporting information.

The application for a licence to prepare site must be accompanied by the appropriate regulatory fee as outlined in the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*.

The information in an application for a licence to prepare site and its referenced documents satisfies several primary purposes:

- provides the safety case for the site preparation phase of the project, which in turn is incorporated into the licensing basis for the site preparation activities
- documents the conditions of the site and surrounding region that must be addressed in any technologies being considered, and associated safety and control measures
- demonstrates that any technologies under consideration for the site will be able to withstand the conditions imposed on the nuclear facility by the site and its surroundings
- demonstrates that the site is suitable for a reactor facility's full lifecycle

This regulatory document does not presuppose or limit an applicant's intention to implement a particular kind of technology in future licensing phases.

For an applicant to obtain a licence to prepare site, the CNSC may request additional information from the applicant to further substantiate claims made in the application or to address any gaps found in the application.

Appendix A is a licence application guide for an application for a licence to prepare the site.

3. Site Evaluation for New Reactor Facilities

This section sets out the CNSC's requirements and guidance for the evaluation of sites for new nuclear power plants and small reactor facilities (referred to as reactor facilities).

Site evaluation is a process that continues throughout the lifecycle of the proposed facility, to ensure that the facility's design basis and safety case remains current with changing environmental conditions or modifications to the facility itself. Site evaluation information is also a key input into reactor facility design and subsequent lifecycle phases.

Site evaluation covers a substantial part of an environmental assessment (EA) conducted under federal environmental assessment legislation. Information gathered through the site evaluation process should be used during the EA process, and will be reviewed by the CNSC during the assessment of all licence applications in the facility's lifecycle, in particular for the licence to prepare site.

Site evaluation should begin before the submission of an application to prepare a site for the construction of a reactor facility. Site selection is not regulated under the NSCA, and is not addressed as a regulatory requirement in this document. However, the applicant should ensure that the site is evaluated at a level sufficient to confirm the suitability of the site for the activity.

As stated in section 2, the licensing of reactor facilities in Canada involves several steps, beginning with consideration of the proposed site, conduct of the environmental assessment and issuance of a licence to prepare site. For more information on the CNSC's EA and licensing processes, see:

- REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2]
- REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, Version 2 [3]

Note 1: Data and analysis results from site evaluation may be used to satisfy information needed for subsequent licensing phases, as specified in the NSCA and associated regulations.

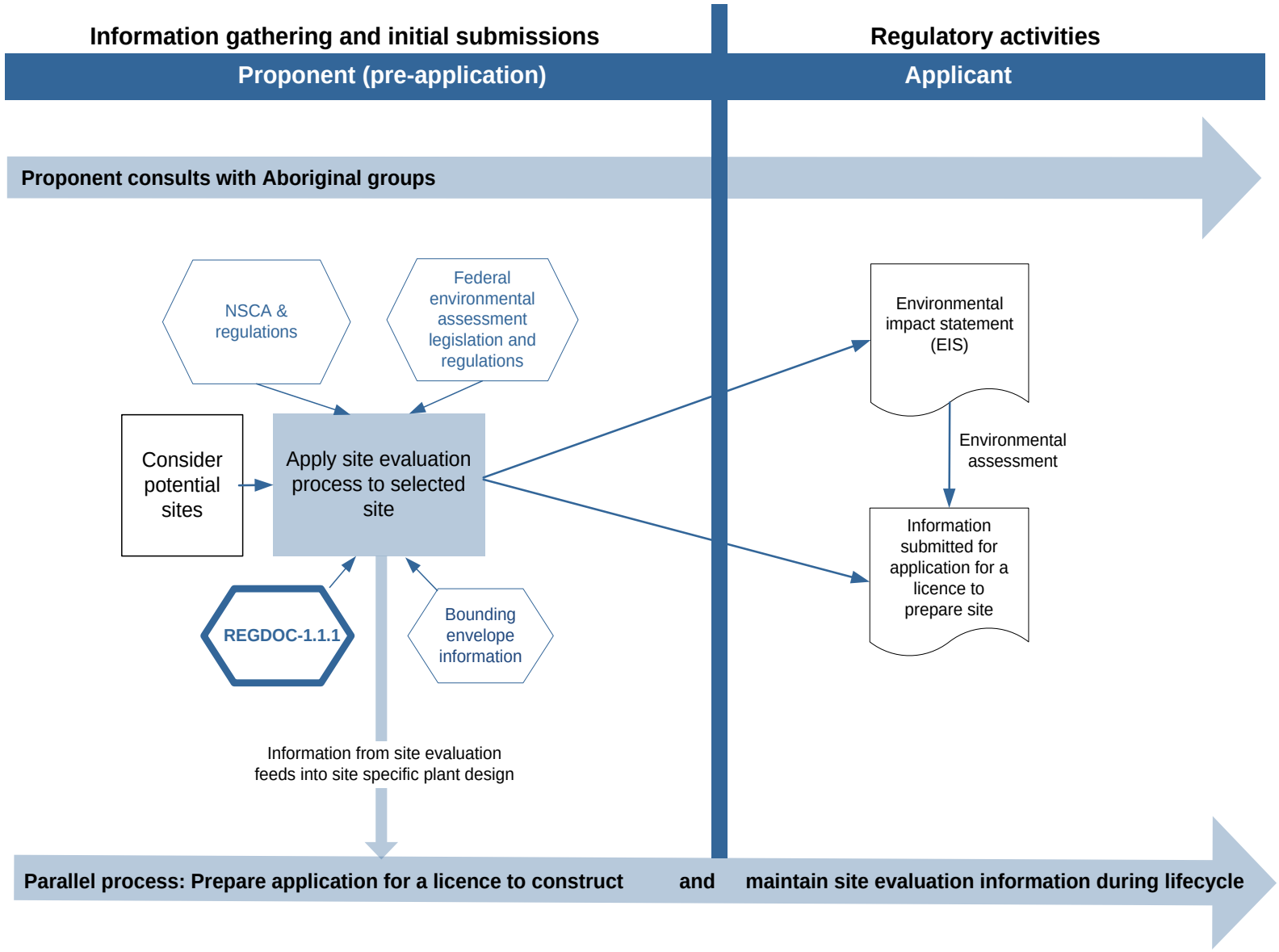
Note 2: The applicant should reject any unacceptable or inappropriate site before applying for a licence to prepare site, without requiring CNSC involvement. Submission of site evaluation information on rejected sites is not required.

3.1 Role of site evaluation in the CNSC regulatory process

Figure 1 shows where site evaluation fits within the initial stages of reactor facility development, and shows the role of site evaluation in the CNSC regulatory process. Site evaluation is part of the information gathering and initial submission activities for the proposed site and includes public and Aboriginal consultations. This information provides input to future environmental assessments, environmental impact statements, and licence applications (such as licence to prepare a site, licence to construct, and licence to operate). For more information about the Crown's duty to consult, see REGDOC-3.2.2, *Aboriginal Engagement* [5].

The results of the site evaluation, especially the site characterization, are used as inputs into the facility design, supporting safety analysis and licensing processes. For more information, see REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6].

Figure 1: The role of site evaluation in the CNSC regulatory process



In accordance with CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7], the site evaluation is periodically re-evaluated. The re-evaluation focuses on confirmation of the site characteristics (in particular, external events) and assessing the effects of the updated information. Design modifications, updates to operations, or both may be needed.

Site evaluation information is also carried through to subsequent facility lifecycle phases. For example, facility design and safety analysis information are assessed as part of the reviews of applications for licences to construct and to operate a nuclear facility.

3.2 Site evaluation methodology

The methodology of site evaluation typically involves conducting a site survey to identify one or more candidate sites, and then performing a detailed evaluation of those preferred sites to:

- minimize the effects of the proposed reactor facility on the environment
- minimize the effects of the environment on the ability of the reactor facility to operate within the defined safe operating envelope
- identify mitigation strategies that may be needed (if the site is selected for the proposed reactor facility) to reduce risk to national security, health and safety, and the environment

An additional goal of the site evaluation process is to anticipate satisfying the requirements of the NSCA and the regulations made under it by providing technical data that will be used in processes related to the design, construction, operation, and eventual decommissioning and abandonment of the reactor facility.

Site characteristics and the effects of external events are integral considerations in the site evaluation process:

- they may be used in assessing the risks to both the reactor facility and the environment, and in determining the mitigation strategies required to minimize those risks and their consequences
- mitigation strategies feed into reactor facility site preparation and design through various safety assessment processes
- site characteristics and associated risks feed into the public and Aboriginal consultation processes
- emergency preparedness and security readiness ensure that adequate measures can be implemented at the appropriate licensing stages

The degree of focus given to external events depends on their probability and severity. The amount of focus given to site characteristics depends on their ability to influence postulated events and contribute to an increased risk of adverse effects on the environment or on health and safety, or to adversely affect the execution of emergency response measures.

3.3 General criteria for site evaluation

A detailed and methodical site evaluation, using a graded approach commensurate with the risks posed by the proposed reactor facility, is essential in preparing site mitigation strategies (including emergency response plans) that will adequately protect the facility personnel, the public and the environment from the effects of nuclear and hazardous substances arising from licensed activities.

Requirements for site evaluation

Site evaluation shall take into account all phases of the facility lifecycle, from site preparation to abandonment. The applicant shall:

- use a documented, systematic process for site evaluation (including site characterization)
- consider the synergy of multiple simultaneous events (for example, combinations of external hazards, reactor facility events including beyond-design-basis events and severe accidents, and multiple effects of different activities on the site)

For analysis of external hazards, the applicant shall consider both design-basis events and beyond-design-basis events. In particular, the applicant shall consider the concept of potential cliff-edge effects when analyzing external hazards, where a small change of conditions may lead to a catastrophic increase in the severity of consequences.

For reactor facilities, the applicant shall analyze external hazards at the site evaluation stage, to confirm that the reactor facility will withstand such events.

Evaluation of the suitability of a site for the construction and operation of a nuclear facility shall address the following considerations:

- population density, population distribution and other characteristics of the emergency planning zone that may have an effect on the implementation of emergency response measures and the need to evaluate the risks to individuals and the general population
- the technical basis for the safety and security analysis issues that will be included in the licence application (particularly important for the licence to prepare site), including the range of technologies being considered and the estimated total power for the reactor facility
- categorization and assessment of the characteristics of the natural and human environment in the region that may be affected by potential radiological or conventional effects associated with site preparation and construction, operational states, and accident conditions
- predictions about the evolution of the natural and human environment in the region, particularly population growth and distribution, which may have a bearing on safety and security throughout the projected lifecycle of the reactor facility
- storage and transport of input and output materials – such as fresh and spent fuel, and radioactive waste
- information about non-radiological effects due to chemical or thermal releases, or other site activities such as damage to aquatic organisms from entrainment into cooling water intakes, or physical disruption of landscape and shoreline from site development, and the potential for explosion and the dispersion of chemical products
- as far as practicable, information about the potential for interactions between nuclear and conventional effluents, such as the combination of heat or chemicals with radioactive material in liquid effluents
- predictions about the reactor facility's effects on the population, including those that could lead to emergency conditions, with due consideration of relevant factors (for example, population distribution, use of land and water, radiological effect of any other releases of radioactive material in the region)
- hazards associated with natural and human-induced external events, including future alterations of magnitude and frequency due to effects of climate change
- evaluation against safety goals

In evaluating the site, the applicant shall also take into account the combined radiological and conventional effects of the site and the reactor facility on each other during normal and abnormal situations, based on both temporal (lifecycle) and spatial (regional, local and site) considerations.

The applicant shall periodically review site-specific hazards using updated knowledge. Potentially significant changes in hazards (for example, in light of feedback of operating experience, a major accident or extreme events) should be evaluated in a timely manner.

For more information, see appendixes B, F and G.

Guidance

The applicant should provide a high-level overview of alternate sites considered prior to selecting the proposed site, including a brief description of the degree and depth of site evaluation used to narrow down the final choice(s).

If the site evaluation indicates deficiencies for which design features, site protection measures, or administrative procedures cannot compensate, the site should be deemed unacceptable or inappropriate. (As stated in note 2 above, the applicant should reject any unacceptable or inappropriate site before applying for a licence to prepare a site. Submission of site evaluation information on rejected sites is not required.)

The applicant should describe how the characteristics of the natural and human induced hazards, as well as the demographic, meteorological and hydrological conditions of relevance to the nuclear installation, will be monitored over the nuclear facility's lifecycle.

3.3.1 Evaluation against safety goals from a site perspective

The applicant shall evaluate reactor facility designs against applicable safety goals, taking into account the characteristics of the site, the risks associated with external hazards (including any potential cliff-edge effects that may arise from small increases in the severity of external hazards), and the potential negative effect of the reactor facility on the environment. The evaluation shall include the effects of multiple unit events and – where applicable – effects from events that may affect multiple units.

To support this evaluation, the applicant shall provide a summary of the process by which the different nuclear power plant or small reactor technologies being considered have been included in the site evaluation. Bounding approaches for site evaluation may be considered; however, bounding limits for a proposed facility must be based on credible information from designs being considered for that site.

For more information on safety goals related to quantitative and qualitative safety goals, see appendices B through G, and REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6].

3.3.2 Consideration of the evolution of natural and human-induced factors

The applicant shall evaluate the evolution of natural and human-induced factors in the environment that may have a bearing on safety and security across a time period that encompasses the projected lifecycle of the reactor facility, with the understanding that different levels of evaluation and monitoring apply to the various phases of the reactor facility's lifecycle.

For more information, see appendices B and F.

3.3.3 Evaluation of hazards associated with external events

The applicant shall examine the site with regard to the frequency and severity of external natural and human-induced events that could affect the safety and security of the reactor facility. The analysis shall include an examination of potential cliff-edge effects that may arise from small increases in the severity of events. This information provides a baseline for future assessments over the life of the facility.

The applicant shall apply a systematic approach for identifying and assessing the hazards associated with external events. The approach (including the underlying rationale) shall be developed, documented, and implemented in an auditable fashion.

The applicant shall identify and assess each external natural and human-induced event with the following considerations:

- the potential direct and indirect effects of the event on the reactor facility structures, systems, and components (SSCs), including those that could affect the safe operation of the reactor facility in both normal and abnormal operating states:
  - direct effects (for example, an earthquake resulting in a main steam line break)
  - indirect effects (for example, a corrosive gas release from a nearby chemical plant degrading reactor facility safety system trip circuits via ventilation intakes)
- the potential combined effects of external and human-induced events with normal and accidental releases from the reactor facility that would exceed environmental limits, or cause a significant adverse effect to occur
- effects of natural external and human-induced events – including consequential events (that is, events that arise as a consequence of an initiating event) or reasonable combinations of independent events – that could influence the ability to successfully implement emergency response plans

Derivation of the hazards associated with external events shall include consideration of the combined effects of these hazards with the ambient conditions (for example, simultaneous aircraft crash and heavy snowstorm). Combined effects of external hazards can have significant effects on such facets of the reactor facility as the implementation of emergency response plans, accident mitigation, and contaminant dispersion.

The region assessed for each identified external event shall encompass the environment that could be affected.

The evaluation shall consider foreseeable changes in land use for the projected lifecycle of the reactor facility, in order to assess and plan for mitigation of new external hazards introduced by changes in land use.

For more information, refer to appendix F.

Guidance

Site-specific data should be used to determine hazards, unless such data is unobtainable. In this case, data from similar regions that is sufficiently relevant to the region of interest, or data

derived from appropriate and acceptable simulation techniques, may be used. Data from similar regions and from simulated findings may also be used to augment site-specific data.

Prehistoric, historic, and instrumentally recorded information, and records of the identified external events and their severity, should be collected for the region and analyzed for reliability, accuracy, and completeness.

3.3.4 Determining the potential effect of the site on the environment

During site evaluation, the applicant shall take into account considerations such as those listed in table A to minimize the potential effect of the site's interaction with the environment (such as moving, destroying or substantially altering rare or sensitive habitats, biota, or areas of socio-economic importance), including the structural, compositional, and functional components of its biodiversity.

Table A describes considerations with respect to specific areas and activities that may be particularly sensitive to such interaction.

Table A: Potential effects – considerations for special areas or activities

Areas or activities	Considerations
Habitats essential to maintaining the viability of valued components (VCs), and designated protected habitats (national or provincial parks, reserves, etc.)	1) Assess and minimize any potential interaction with critical habitats, or with individuals or species of conservation status. 2) Assess and minimize any potential for destruction or substantial alteration of breeding, nesting, or spawning habitats. 3) Assess and minimize any potential for destruction or substantial alteration of other critical habitats to VCs, such as over-wintering, feeding, or nursery habitats.
Areas containing migratory routes of VCs.	Assess and minimize any potential for compromising these natural heritage features that are used by VCs for migration, which may be site- or region-specific, and may include woodlands, wetlands, meadows, valley lands, estuaries, and the shorelines of streams and lakes.
Areas of high biological production (for example, staging, feeding and rearing grounds for numerous VCs) and their connecting links or buffer zones.	1) Assess and minimize any potential for compromising these natural heritage features, which may be site- or region-specific, and may include woodlands, wetlands, meadows, valley lands, estuaries, and the shorelines of streams and lakes. 2) Consider that wetlands, salt marshes, mud flats, aquatic littoral zones, and offshore shoals may need buffer zones to protect areas of critical biodiversity functions from adverse effects such as contaminants and intrusions.

The applicant shall examine the site with respect to the risk from nuclear and hazardous substances to the public and the environment. These risks are to be kept as low as reasonably achievable. Risks include the effects of thermal pollution on surrounding bodies of water, and the effects of long-term onsite nuclear waste management.

The applicant shall consider the synergy of multiple events. Some examples of such events are:

- those that affect multiple units, including those leading to severe accidents
- multiple effects of several different activities, such as simultaneous oil spill and fire
- spills of multiple chemicals and interactions thereof

Contaminant (nuclear and hazardous substances) pathway modelling shall incorporate atmospheric dispersion, surface water dispersion, and groundwater movement, as well as the associated abiotic and biotic environmental compartments.

Models used for dispersion and pathways analyses shall include site-specific, local, and regional topographic features and characteristics of the reactor facility, and take into account natural and human-induced events that may influence contaminant behaviour.

The pathways analyses shall take specific environmental and site characteristics into account, with special attention paid to the function of the biosphere in the accumulation and transport of nuclear and hazardous substances.

To determine the potential contaminant effect on the environment, assessments of all releases shall be made under normal and accident conditions for all phases of the reactor facility's lifecycle. This assessment shall include an examination of potential releases from multiple unit events, or events affecting multiple units.

For additional information, refer to appendices B, F, and G.

Guidance

The applicant should complete bounding scenarios involving modelling of potential effects from maximum possible releases, in order to establish the outer boundaries or worst-case scenarios for the reactor facility. These bounding scenarios also contribute to the scenarios used for emergency planning.

Assessments of releases or disturbances associated with normal or routine operations should be based on expected performance (for example, average concentrations) and upper threshold bounding conditions, as well as possible pulse releases (high concentration with short exposure period) from anticipated operational occurrences.

The locations of the reactor facility and of the subsidiary structures on the site should be examined at a high level, with the assistance of environmental modelling. Such structures should be located so as to minimize potential effects on the public and on the environment (for example, emission or effluent release points, and air or water intake structures).

The estimates of releases and disturbances used in risk modelling should be re-evaluated during the assessment of the construction licence application, when the design and safety features of the reactor facility have been confirmed. The applicant should re-evaluate risk modelling continually, as operating experience is gained over the reactor facility's lifecycle.

The applicant should identify reference areas that will be unexposed to project interactions but close enough to be similar to the special areas or activities (see table A). These reference areas are used to detect project effects relative to changes in background conditions. Reference areas should be sampled during baseline conditions to establish the natural differences from exposure sites. The baseline should be characterized sufficiently to allow for a statistically significant assessment of project effects. Two or more reference areas should be identified, in order to characterize natural spatial variability in measured parameters as a "noise" factor to be accounted for when monitoring to detect project effects.

For more information, see:

- IAEA Safety Standards Series No. NS-G-3.2, *Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants* [8]
- appendices B, F, and G of this regulatory document

3.3.5 Population and emergency planning considerations

An exclusion zone is "a parcel of land within or surrounding a nuclear facility on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control" (see REGDOC-3.6, *Glossary of CNSC Terminology* [9]).

To support the achievement of safety objectives, the site evaluation shall take the following population and emergency planning considerations into account:

- the planning basis as described in REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, version 2 [10]
- population density, characterization and distribution within the emergency planning zone, with particular focus on existing and projected population densities and distributions in the region including resident populations and transient populations (note: this data is to be kept up to date over the lifecycle of the reactor facility)
- present and future use of land and resources
- physical site characteristics that could impede the development and implementation of emergency plans (for example, the ability to deliver fuel in a timely manner to backup generators)
- populations, including vulnerable populations, in the vicinity of the reactor facility that are, or may become, difficult to evacuate or shelter (for example, schools, prisons, hospitals)
- ability to maintain population and land-use activities in the emergency planning zone at levels that will not impede implementation of the emergency response plans

Before submitting the application for a licence to prepare site, the applicant shall confirm with the surrounding municipalities and the affected provinces, territories, foreign states, and neighbouring countries that the implementation of their respective emergency plans and related protective actions will accommodate the lifecycle of the proposed project. Discussions around early plans shall include plans and consideration of the following:

- onsite response, including the capacity to bring offsite equipment onsite
- ability of offsite licensee staff to communicate with and access the site during a catastrophic event
- offsite response, and how it is coordinated between the licensee and federal, provincial and municipal government agencies playing a role in emergency preparedness and response

- how the licensee will coordinate with regulatory bodies
- how the licensee will respond and coordinate with emergency service providers (fire department, ambulance, hospital, fuel, food, and so on)

The applicant shall document the strategy and process for effective two-way ongoing consultation with emergency management agencies affected by site operations throughout the project's lifecycle. Emergency management agencies include security agencies involved in the development of the site selection threat risk assessment report.

Guidance

Because of the time required for this task, the applicant should initiate these discussions during the early stages of site evaluation. The CNSC expects these agreements to be in place before granting a licence to prepare site.

The emergency planning zones are established by the province or territory and are under control of the region or municipality. These zones cover the area beyond the exclusion zone that should be considered with respect to implementing emergency measures.

3.3.6 Consideration of future life-extension activities

Where appropriate, the applicant shall consider the potential effects of longer service life, power uprate activities and modifications to accommodate additional or modified uses:

- any proposed longer period of service life for the reactor facility
- additional conventional and nuclear waste generated, as well as estimated resulting effects on handling, transport, and storage of waste
- effects of external and human induced events on the life extension, power uprate and/or modification activities
- effects on security and emergency planning

Guidance

Life extension involves the replacement or refurbishment of major components, or substantial modifications to the plant, or both.

Anticipated power uprate projects represent early plans to seek to use reactor facility design margins and future operating efficiencies and experience, in order to increase reactor facility output capacity by some degree.

Power uprate projects may also require plant modernization activities, in order to maintain compliance with the NSCA and associated regulations.

For small reactors, in particular research reactors, the licensee may seek, at some point during the lifecycle of the reactor, to modify the design in order to accommodate additional uses (such as new or alternate medical isotope production, or district heating).

3.4 Gathering Baseline Data

The applicant shall document and demonstrate a systematic process for gathering baseline data, and shall include analysis of variability and uncertainties. Baseline data shall be captured within auditable management systems, quality management or quality assurance programs.

The baseline data shall consider valued components (VCs) [9]. The applicant shall describe the general criteria used to identify VCs that may be affected by the project. The applicant shall identify VCs in the existing environment and use them as specific assessment end-points. The applicant shall identify measurement end-points, as appropriate.

The baseline data shall also consider contaminants of potential concern (COPCs) associated with historical, present or proposed future use of the site. An understanding of COPCs prior to collecting environmental baseline data will direct the selection of parameters to be included in the environmental baseline data collection program.

The applicant shall verify the baseline data collected in the initial assessment in subsequent periodic assessments carried out over the life of the facility.

For more information, see section 4.5 and appendices A (section 6.3), B and C of this regulatory document.

Guidance

Where possible, baseline data should take into account archeological, paleontological, and prehistoric data (including the oral history of Indigenous peoples), as well as historic and instrumentally recorded sources.

Baseline data should be of sufficient sample size and duration to obtain a basic understanding of within-year and between-year variation. For more information on specific baseline environmental components, see appendix B.

As described in CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11], the proposed operational monitoring program may require additional intensive baseline sampling for monitoring elements where a specific level, effect, or change in the environment is detected.

All provincially or federally listed wildlife species occurring or reasonably expected to occur, within the spatial boundaries should be identified as VCs.

For more information, see:

- CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7] (note that CSA N288.6-12 refers to VCs as receptors)
- REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2]
- IAEA Safety Standards Series No. SSG-9, *Seismic Hazards in Site Evaluation for Nuclear Installations* [12]
- IAEA Safety Standards Series No. NS-G-1.5, *External Events Excluding Earthquakes in the Design of Nuclear Power Plants* [13]
- IAEA Safety Standards, Series No. NS-G-3.6, *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants* [14]
- IAEA Safety Standards Series, Specific Safety Guide No. SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15]
- NUREG/CR-7046, PNNL-20091, *Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America* [16]
- NUREG/CR-7005, *Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants* [17]

3.4.1 Atmospheric and meteorological data

The applicant shall provide a description of the ambient air quality in the study areas, with emphasis on those parameters for which there will be radiological and non-radiological emissions resulting from the project.

A comprehensive site evaluation relies on understanding how meteorological phenomena may affect the site. The evaluation shall take into account instrumentally recorded climate data sources that reflect the regional conditions, such as the "Canadian climate normals" webpage [18].

Descriptions of basic meteorological variables shall include:

- wind speed and direction
- air temperature
- precipitation
- humidity
- atmospheric pressure

The applicant shall prepare and carry out a program for meteorological measurements at – or near – the site, with the use of instrumentation capable of measuring and recording the main meteorological variables at appropriate elevations, locations, durations and time intervals.

Guidance

This program initially provides data for site evaluation, and then provides ongoing data for use in revisions to basis documents in response to safety analysis results during future phases of the reactor facility's lifecycle.

The evaluation should also take into account prehistoric and historic climate data sources that reflect the regional conditions.

3.4.2 Geological data

In the site evaluation, the applicant shall include a description of the regional, local and site geology and a description of important geological structures.

The applicant shall investigate the geotechnical properties of the overburden, including shear strength and liquefaction potential. The geotechnical properties support the assessment of slope stability and the bearing capacity of foundations under both static and dynamic conditions.

3.4.3 Geophysical data

The applicant's site evaluation shall describe the site's seismotectonic data, including (but not limited to) information on prehistoric, historic and instrumentally recorded seismic activity in the region.

Information on geophysical hazards shall include the influence of surface faults on seismic activity in the region.

3.4.4 Hydrological data

The site evaluation shall describe surface water hydrology, including delineation of the drainage basins and available prehistoric, historic, and instrumentally recorded hydrological data, such as water levels and flow rates.

The applicant shall carry out a program of hydrological investigations using both deterministic and probabilistic approaches as appropriate, so as to permit the assessment of normal flow, flooding, and drought properties of water bodies, as well as the interactions between surface water and groundwater flow systems. This program shall include predictions of changes to site surface water hydrology (flows and chemistry) that are expected from foreseeable changes in upstream land use

The applicant shall gather baseline surface water and sediment quality data and provide that data as part of the site evaluation.

3.4.5 Hydrogeological data

The site evaluation shall describe the hydrogeology of the local environment, including the groundwater distribution, groundwater quality, and physical and geochemical properties of water-bearing formations (hydrogeological units) and their interactions with surface waters.

The applicant shall carry out a program of hydrogeological investigations to permit the assessment of groundwater distribution and flow, as well as radionuclide and other contaminant movement in the hydrogeological environment. This program shall include predictions of the interaction between the project and the hydrogeology, including changes to the site hydrogeology (groundwater distribution, groundwater flows and chemistry, and migration of COPCs) that are expected to result from foreseeable changes in upstream land use the project or migration of existing contaminant plumes.

The applicant shall gather baseline groundwater quality data and provide that data as part of the site evaluation.

3.4.6 Biological data

The applicant shall identify and document the biotic characteristics of the proposed site, taking into account the environmental considerations set out in table A. The site evaluation shall provide documentation of the biota using the habitat at the proposed site, and shall include descriptions of vegetation communities, birds, mammals, reptiles, fish, and invertebrates that could be used for the environmental effects monitoring and risk assessment purposes.

This information is used to:

- identify likely interactions between the project and the biota in the area
- predict potential environmental effects
- identify mitigation measures
- evaluate the significance of the residual effects once the mitigation measures are applied
- develop a follow-up monitoring program

Guidance

Biological data plays an important role in identifying VCs, which are used as the final receptors in pathways modelling.

3.4.7 Baseline ambient radioactivity and pre-existing hazardous substances

The applicant shall characterize the overburden and any bedrock to be removed with respect to both natural and anthropogenic sources, so as to assess any conventional and radiological risks to health, safety, and the environment. Where an area on the site has received substantial contamination from previous nuclear or non-nuclear industrial activities, the baseline characterization shall consider nuclear and hazardous substance levels within biota and relevant environmental media of interest. The presence of contamination may result in the need for a radiation protection program during site preparation activities (see section 4.7).

Prior to active commissioning of the nuclear installation under a licence to operate, the applicant shall assess the ambient radioactivity of the atmosphere, hydrosphere, lithosphere, and biota in the region, including an assessment of ambient radionuclide activity levels in ingested water and food used in the human pathways modelling.

3.5 Evaluation of Natural External Events

The applicant shall develop, document and implement a systematic approach for identifying all natural external events. The assessment shall address environmental effects over the lifecycle of the proposed facility.

Guidance

Some examples of the hazards to be considered are:

- climate change
- meteorological hazards
- surface water hazards
- groundwater hazards
- geotechnical hazards
- geophysical hazards
- biological hazards
- natural fire hazards

For more information, see:

- appendices B and D of this regulatory document
- IAEA Safety Standards Series No. SSG-9, *Seismic Hazards in Site Evaluation for Nuclear Installations* [12]
- IAEA Safety Standards Series No. NS-G-1.5, *External Events Excluding Earthquakes in the Design of Nuclear Power Plants* [13]
- IAEA Safety Standards, Series No. NS-G-3.6, *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants* [14]
- IAEA Safety Standards Series, Specific Safety Guide No. SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15]
- NUREG/CR-7046, PNNL-20091, *Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America* [16]
- NUREG/CR-7005, *Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants* [17]

3.5.1 Climate change

In their evaluation of natural external events, the applicant shall consider potential climate change over the projected lifecycle of the reactor facility.

Guidance

Climate change can potentially influence all of the other natural external events (some examples are shown in table B).

Table B: Potential influence of climate change on other natural external events

Natural external event	Examples of potential influence of climate change
Meteorological factors	Averages and extremes of temperature, humidity, evaporation, high winds, abrasive dust and sand storms, precipitation, lightning
Surface water hazards	Water supply, magnitude and frequency of floods and droughts, storm surges
Groundwater hazards	Groundwater levels, flow pattern and velocity change resulting from changes in surface water recharge and evaporation
Geotechnical hazards	Stabilities including landslides related to changes in permafrost, surface water levels, such as in rivers, seas and lakes, and groundwater flow systems
Geophysical hazards	Magnitude and frequency of earthquakes and avalanches, and so on, due to changing sea and lake levels and melting glaciers
Biological hazards	Biological community, population and distribution changes due to temperature and humidity changes
Natural fire hazards	Changes in temperature and vegetation cover

3.5.2 Meteorological hazards

Temperature and humidity

The applicant shall include the following potential factors in the assessment of temperature and humidity:

- effects of sudden or prolonged extreme temperatures on future reactor facility SSCs that will be important to safety (for example, cooling air intakes)
- effects of condensation and evaporation on future reactor facility SSCs that will be important to safety (for example, electronic components)
- potential for temperature and humidity to affect releases from the reactor facility into the environment and to affect the temperature of the condenser cooling water

High winds

The applicant shall assess the frequency and intensity of strong winds, including tornadoes and hurricanes, on the basis of historic and recorded data for the region.

Guidance

The applicant should include the following potential factors in the assessment:
- wind and pressure-loading effects
- wind-propelled missiles that could affect SSCs, or that could render offsite power supplies unavailable
- effects on emergency plan execution
- possibility of affecting releases from the reactor facility into the environment

Abrasive dust and sand storms

The applicant shall assess the risk of dust and sand storms on the basis of historic and recorded data for the region, and should include consideration of the following potential factors:
- abrasion or erosion of SSCs
- effects on air or water intakes
- effect of static electricity generation on electrical or electronic SSCs
- effects on offsite power supplies to the site
- effects on emergency plan execution
- possibility of affecting releases from the reactor facility into the environment

Precipitation

The applicant shall assess all types of precipitation on the basis of historic and recorded data for the region. The assessment should take into account the potential effects on:
- structural loading, including acute effects from heavy precipitation, such as hail
- cooling air or water intakes
- offsite power supplies to the site
- dispersion of releases from the reactor facility through surface or groundwater
- emergency plan execution
- possibility of affecting releases from the reactor facility into the environment

Lightning

The applicant shall evaluate the frequency and severity of lightning to determine potential effects on the reactor facility, including the influence of lightning events on the risks of natural fire.

3.5.3 Surface water hazards

Floods

The applicant shall assess the region to determine the potential for flooding due to natural causes that may affect the safety of the reactor facility. The external flood could be caused by several hydrometeorological, geoseismic, or structural-failure phenomena, such as runoff from precipitation or snow melt, high tide, storm surge, tsunamis or wind waves.

The applicant shall determine the design-basis flood. A design-basis flood is caused by one or an appropriate combination of several hydrometeorological, geoseismic, or structural-failure phenomena, which results in the most severe hazards to SSCs important to the safety of the reactor facility.

Guidance

For more information (taking into consideration site-specific hydrological characteristics), refer to:

- IAEA Safety Standards Series No. NS G-1.5, *External Events Excluding Earthquakes in the Design of Nuclear Power Plants* [13]
- IAEA Safety Standards Series No. SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15]
- NUREG/CR-7046, *Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America* [16]

These guidance documents reflect best international practice in flood hazard assessment. Conforming to the guidance, taking into consideration site-specific hydrological characteristics, will demonstrate the adequacy of flood hazard assessment.

Adequacy of water supply

Evaluation of water supplies to the site shall include the following components:

- surface and groundwater sources
- quantity and quality of water
- reliability and availability of supply

The evaluation shall also include consideration of the potential effects of:

- debris and fouling
- additional water requirements for emergency cooling or process needs
- effects on contaminant transportation
- fluctuations in water temperature that could affect heat sinks
- effects on firefighting capability

3.5.4 Groundwater hazards

The applicant shall use a program of hydrogeological investigations, based on groundwater probing, monitoring data, and numerical modelling, to assess the potential effects of the groundwater flow system (groundwater level and quality) on the reactor facility, such as:

- effects on the stability of the reactor facility's foundations
- effects on the integrity of the reactor facility's below-grade structures, such as wet storage bays

3.5.5 Geotechnical hazards

The applicant shall examine geological maps and other appropriate reference sources for the region to determine the existence of natural features that could affect the surface and subsurface stability of the site.

The applicant shall assess the stability of the foundation material under dynamic, static, and seismic loading, with a detailed description of surface and subsurface conditions (including

hydrogeochemical effects) being incorporated into a geotechnical investigation program for the purposes of hazard determination and mitigation. The investigation shall describe any potential site instability, such as collapse, subsidence, surface uplift, and liquefaction of the subsurface materials and the backfill materials.

The applicant shall analyze the stability of natural slopes and human made features such as mines, cut slopes, dams and embankments, and waste stockpiles under static, dynamic, and seismic loading, using site-specific data to assess their potential effects on the nuclear facility.

The applicant shall assess settlements (magnitude and rate) of foundations and/or foundation soils caused by large surface loadings and/or underground water drainage, using project-specific data. The applicant shall also analyze differential settlement and soil distortion as required to assess their potential effects on the nuclear facility.

For underground excavations, the applicant shall analyze underground instability (rock falls and underground collapses) and groundwater inflow using site-specific geotechnical and hydrogeological data to assess the potential risks to worker safety.

3.5.6 Seismic and geological hazards

Earthquakes

The applicant shall conduct a seismotectonic evaluation for the region, using geophysical data and information on geotechnical hazards. The applicant shall evaluate the potential effects that seismic events and faults may have on sub-surface contaminant transport for the region.

For the final selected site to be referenced in an application for a licence to prepare site, the applicant shall prepare a site-specific seismic hazard assessment, including a paleoseismic investigation and probabilistic seismic hazard analysis to develop ground motion response spectra.

For nuclear power plants, the applicant shall conduct the assessment in accordance with the latest approved version of CSA N289.2, *Ground motion determination for seismic qualification of nuclear power plants* [19].

Surface faulting

The applicant shall include an assessment of whether a fault or any part of a fault is capable, on the basis of geological, geophysical, geodetic, or seismological data (including paleoseismological, geomorphological data, etc.).

Where applicable, the applicant shall evaluate the tsunami risk from earthquakes and/or landslides.

Guidance

A capable fault is a fault that has exhibited one or more of the following:

- evidence of past movement along the fault, which occurred within the appropriate assessment time span; the assessment time-span is proportional to the earthquake recurrence interval or, movement along the fault that has occurred within the last 35,000 years (note: for highly active regions with short earthquake recurrence intervals, the time frame is shorter)

- a structural or macro-seismically determined (with instrumentation) relationship with a known capable fault, such that movement on one may be expected to result in movement on the other
- the maximum potential seismic event associated with the fault is sufficiently large enough that it is reasonable to infer that movement at (or near) the surface could occur

In some cases, surface evidence of past fault activity may be obscured at a particular site (for example, where overburden is very thick). In such instances, geological evidence from elsewhere along the fault within the vicinity of the site may be used to evaluate surface faulting, and to determine if a fault is a capable fault.

For more information, see:
- section 3.5.5 of this regulatory document
- NRC Regulations (10 CFR), *Appendix A to Part 100 – Seismic and Geologic Siting Criteria for Nuclear Power Plants* [20]

Volcanic hazards

Where applicable, the applicant shall provide an evaluation of the potential for a volcanic event to occur that could affect the safe operation of the reactor facility. The evaluation shall include:
- all available information (both recorded and those available from geoscientific studies and historical accounts) on volcanic activity that has occurred in the region
- characteristics of potential volcanic event, such as tectonic setting, type of volcanism and nature of material produced during eruption including volatile gas emissions
- potential effects on ventilation systems
- volcanic missiles that could affect SSCs
- potential abrasion or chemical effects on SSCs
- effects on air and water intakes
- effects of static electricity generation on electrical or electronic SSCs
- effects on offsite power supplies to the site
- effects on emergency plan execution

For more information, see IAEA SSG-21, *Volcanic Hazards in Site Evaluation for Nuclear Installations* [21].

3.5.7 Biological hazards

Site evaluation shall include consideration of the biological phenomena that may pose a risk to the safe operation of the reactor facility.

The evaluation shall also consider the potential for unusual weather events to increase the risk of ventilation and cooling intake systems being clogged by biota (for example, flooding or large storm events can dislodge large biomasses of aquatic macrophytes, and those biomasses could foul the intake structures).

The evaluation shall consider the potential for the rapid growth of pathogens in the ultimate heat sink and other elements of the cooling system (as it poses a potential risk to both human and non-human biota).

The applicant shall evaluate the potential risk to human and non-human biota from biocides and other means of managing these biohazards.

Guidance

The applicant should pay particular attention to biological phenomena that may pose a risk to cooling water systems. The potential for the colonization and excessive growth of algae, mussels, or clams within these systems, and the clogging of intake structures by large quantities of biological material (such as aquatic plants, fishes, or jellyfish) should be considered.

The applicant should also consider biological hazards (such as those that may be posed by rodents and birds) that damage or disrupt electrical or other systems within the facility.

3.5.8 Natural fire hazards

The applicant shall assess natural fire hazards with respect to their potential risk to reactor facility safety.

3.6 Evaluation of External, Non-Malevolent, Human-Induced Events

The applicant shall apply a systematic approach to identify all external, non-malevolent, human-induced events over the lifecycle of the proposed project. Some examples of such events are:

- aircraft crashes
- other transportation hazards
- fires and explosions
- chemical and radiological hazards
- electromagnetic interference hazards

Information provided shall demonstrate how design information provided in support of site evaluation is credible and sufficient to adequately bound the evaluations of environmental effects.

For more information, see:

- appendix B of this regulatory document
- IAEA Safety Standards Series No. NS-G-3.1, *External Human Induced Events in Site Evaluation for Nuclear Power Plants* [22]
- IAEA Safety Standards Series, Specific Safety Guide No. SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15]
- NUREG/CR-7046, PNNL-20091, *Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America* [16]
- NUREG/CR-7005, *Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants* [17]

3.6.1 Aircraft crashes

The applicant shall assess the potential for aircraft crashes on the site, taking into account the probable characteristics of future air traffic and aircraft. If the assessment reveals an unreasonable risk of an aircraft crash on the site, then an assessment of the associated hazards, including impact, fire, and explosion, shall be conducted.

The site evaluation shall consider the potential effects on emergency plan execution, including effects on evacuation routes.

3.6.2 Other transportation hazards

The applicant shall evaluate present and proposed land and water transportation routes in the region with respect to potential collisions with SSCs, generation of explosions, chemical and radiological hazards, and fires.

The site evaluation shall consider the potential effects on emergency plan execution, including effects on evacuation routes.

3.6.3 Fires and explosions

The applicant shall evaluate all potential fire and explosion events in the region that could affect the safe operation of the reactor facility, including:

- direction and force of pressure waves and their effects on SSCs and unprotected personnel
- temperature effects on SSCs and unprotected personnel
- potential secondary fires and explosions generated by the primary explosion or fire
- release of volatile gases, asphyxiants, or chemicals that could affect safe function of SSCs or harm unprotected personnel
- missiles that could affect SSCs
- effects that could render offsite power supplies unavailable
- potential effects on emergency plan execution

3.6.4 Chemical and radiological hazards

The applicant shall evaluate all chemical and radiological hazards in the region that could affect the safe operation of the reactor facility, with particular focus on:

- activities that involve the handling, processing, transport, and storage of materials with the potential for explosions, or the production of radioactive materials, volatile and reactive gases, or asphyxiants
- effects of the above on SSCs and unprotected personnel, including estimates of overpressure, toxicity, and transport characteristics in air
- secondary chemical interactions on SSCs
- potential effects on emergency plan execution

3.6.5 Electromagnetic interference hazards

The applicant shall evaluate electromagnetic emitters in the region during normal and abnormal operations, with respect to their potential to affect the safe operation of the reactor facility.

Some examples of emitters are:

- telecommunications facilities, including military and civilian radar installations
- particle accelerators or other research facilities using large electromagnetic fields
- high-voltage transmission lines, including the effects of solar storms on transmission

3.6.6 Consideration of future connections to the grid

Where applicable, the applicant shall confirm with the grid owner(s) that, with appropriate grid and plant mitigation measures in place, the location of the reactor facility will not adversely affect the grid. The applicant shall document this confirmation and provide it in the application.

Note: The design and safety analysis against loss of grid events is addressed in the application for a licence to construct.

3.7 Security Considerations

In the development of security-related physical protection objectives for reactor facilities, the applicant shall include the gathering of information about the reactor facility's proposed siting location, in order to study threats or issues presented by the geographical location and characteristics of the proposed site, including potential acts of terrorism. The applicant shall compile the findings from this study in a site selection threat and risk assessment (SSTRA) report (this requirement applies to new sites and to reactor facilities on existing sites). The contents of the SSTRA report may be merged into the licensee's overall security program after the licence to prepare site has been granted.

The SSTRA shall include comprehensive consideration of both physical protection concerns and transportation routes, as described in the following subsections.

The SSTRA report shall be classified as prescribed information, and protected from release under access to information / freedom of information requests, on the basis of national security.

Guidance

Prior to initiating licensing, the SSTRA report provides the basis for identifying physical protection requirements and proposed mitigation strategies, to ensure that all security-related regulatory requirements are met. The SSTRA also identifies security concerns that may render the site undesirable from a security perspective.

For more information, see appendices C and D of this regulatory document.

3.7.1 Physical protection

The proposed physical protection requirements shall ensure that the appropriate detection, delay, and response considerations are taken into account.

Physical protection design requirements are influenced by the site location. Site evaluation shall, therefore, address the physical dimensions of the reactor facility and its surrounding environment, including:

- the topology of the area that can be considered a component of the overall security barrier design (such as line-of-sight view)
- the proximity of various infrastructure elements that could adversely affect physical protection, such as a chemical plant that could release a noxious substance, a hydroelectric dam that could be accidentally or deliberately breached (resulting in flood), or an airport that provides significant flight traffic in the vicinity of the site
- site boundaries
- weather that could factor as a potential impediment to the operability of physical protection systems (that is, systems that monitor the operation of a reactor and which, on sensing an abnormal condition, automatically initiate actions to prevent an unsafe or potentially unsafe condition)
- details pertaining to the establishment of a construction site, such as the positioning of perimeter fences, access and egress points, and storage of construction drawings

Guidance

Reactor facilities located in a remote area bordered by a small population density may require different physical protection considerations than those that apply to reactor facilities located in a large urban area.

Remote areas

The applicant shall evaluate remote sites with respect to the anticipated time required to implement essential response services, including how long it will take offsite armed responders to reach the reactor facility.

Guidance

This aspect of the SSTRA should support early identification of the need for establishing an onsite nuclear response force capability, to ensure that a trained response group is in position during the construction phase of possible target sets (such as vital areas) that are part of the reactor facility.

3.7.2 Transportation routes

The applicant shall consider the transportation routes in the vicinity of the site, to ensure that they are adequately taken into account during future site development activities. The routes to be considered include waterways, land routes and airspace, as described in the following text.

Waterways

The site evaluation shall include assessment of all waterways in the vicinity of the site, from the perspective of physical protection. For example, a waterborne vehicle – or its personnel or contents – may be used in a manner that may pose a threat to the reactor facility (for example, being an explosive risk) to disable operations, equipment, or systems, in an act of sabotage that could have radiological implications.

Land routes

The applicant shall assess all vehicular access land routes in proximity to the site, including rail lines, to determine the security threat they may pose to potential locations of future vital areas.

Guidance

Where possible, the surrounding terrain may be considered as a natural barrier in reducing vehicle-borne explosive risk. Where this is not possible, the applicant should consider delineating areas from which land vehicles must be restricted.

Airspace

The SSTRA shall consider the threats and risks associated with private and commercial airports, including associated flight pathways. This requirement involves discussions with municipal, provincial or territorial, and federal governments to confirm interdiction capabilities and coordinating points of contact.

3.8 Management system

The applicant shall establish a management system when it can be applied to the site evaluation process.

Note: During site evaluation, the applicant should have a management system in place that governs the conduct of site evaluation activities. As part of an application for a licence to prepare the site, the applicant is expected to include a description of the management system as it pertained to site evaluation.

A management system shall include:

- procedures to control the effectiveness of assessments and engineering activities performed in the different stages of the site evaluation process
- appropriate organization, planning, work control, personnel qualification and training, and activity verification and documentation, to ensure that the management system is carried out as effectively as possible
- records of all work carried out in the site evaluation process
- documentation of the results of studies (including models and simulations) and investigations in sufficient detail to permit independent review
- a report that documents the results of all site evaluation work, laboratory tests, and geotechnical analyses and evaluations

The applicant shall use information on frequency and severity derived from the characterization of the hazards resulting from external events in establishing the design basis hazard level for the nuclear installation. Uncertainties in the design basis hazard level shall be taken into account.

These requirements apply to all activities that may influence safety, or that may contribute to the derivation of parameters that will ultimately contribute to the design basis for the site.

Guidance

The site evaluation process is part of the overall management system for the reactor facility (see section 4.4.1 and appendix A.4.1 for further information on management system requirements and guidance). Site evaluation activities are initiated before the reactor facility is established.

The process of establishing site evaluation-related management system parameters should involve technical and engineering analyses, along with judgments that require extensive experience and knowledge. In many cases, the parameters and analyses may not lend themselves to direct verification by inspections, tests, or other techniques that can be precisely defined and controlled. In these cases, evaluations should be reviewed and verified by individuals or groups that are independent of those who did the work.

Feedback associated with experienced engineering judgment and expertise in geotechnical engineering is an important aspect of assuring the quality of the site evaluation process. For example, in the assessment of matters such as liquefaction potential and slope stability, the accuracy of the evaluation results depends heavily on insight into failures that have occurred in comparable situations. The information gathered from these assessments should be documented and analyzed to provide evidence that similar failures will not occur.

In addition to the requirements listed above, a management system should include:

- data control, verification and validation

- data format
- traceability of data
- configuration control (including data, environmental, meteorological, geological, geophysical, survey, hydrological, biological)
- measuring and test equipment
- use and control of computer modelling
- field and laboratory work
- calculations and analyses
- measures to ensure that the results of the site characterization are accurate, complete, reproducible, traceable and verifiable

In addition, the management system may be graded in accordance with the importance to safety of the individual evaluation activity under consideration.

For more information, see:
- IAEA GSR Part 2, *Leadership and Management for Safety: General Safety Requirements* [23]
- IAEA GS-G-3.1, *Application of the Management System for Facilities and Activities* [24]
- IAEA GS-G-3.5, *The Management System for Nuclear Installations* [25]
- CSA N286, *Management system requirements for nuclear facilities* [26]
- CNSC REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2]

3.9 Decommissioning

The site evaluation shall demonstrate how facility decommissioning at the end of the project is being considered in the overall lifecycle of the nuclear facility.

Guidance

As part of site evaluation, the applicant should consider:
- the ease with which the proposed facility can be decommissioned; that is, the facility is designed to be readily dismantled and disposed of in a fashion that minimizes environmental effects
- proximity and transport considerations to recycling, waste storage and disposal infrastructure

For more information, see:
- G-219, *Decommissioning Planning for Licensed Activities* [27]
- CSA N294, *Decommissioning of facilities containing nuclear substances* [28]
- NEA/OECD, *Decommissioning Considerations for New Nuclear Power Plants* [29]
- NEA/OECD, *Applying Decommissioning Experience to the Design and Operation of New Nuclear Power Plants* [30]
- IAEA TECDOC-1657, *Design Lessons Drawn from the Decommissioning of Nuclear Facilities* [31]

4. Site Preparation for a New Reactor Facility

The applicant is required to hold a licence to prepare the site before any work is done on the site. As stated in section 2, no licence will be issued until the environmental assessment (EA) is complete. For more information on submitting an application for a licence to prepare site, see appendix A.

4.1 Role of site evaluation in an application for a licence to prepare site

Site evaluation is integral to an application for a licence to prepare site, and the assessment of the results of the site evaluation is a key part of the activities carried out under a licence to prepare site. The application for a licence to prepare the site builds on the information gathered from the site evaluation, and should demonstrate that the applicant is taking into account future steps in the lifecycle of the proposed facility (construction, operation, decommissioning, and abandonment).

Site evaluation also provides input information for construction, operation, decommissioning and abandonment:

- for construction, the results of the site evaluation and, in particular, the site characterization are considered in the facility design and supporting safety analysis, which are in turn assessed as part of the review of a construction licence application.
- for operation of the reactor facility, the site evaluation information is considered in the design and licensing basis, and carried through to the subsequent lifecycle phases, including the licence to operate. Information gathered during site evaluation, including the assumptions and bounding envelope would be reconfirmed at the continuing operation phase (this information would also be considered as part of the suite of modern codes and standards during a periodic safety review).
- for decommissioning and eventual abandonment, the site evaluation is useful for the development of early strategies and plans to support the eventual dismantling of the facility and the management of waste, and to establish appropriate financial guarantees.

4.2 Site preparation activities

Site preparation activities may involve construction of facility structures, systems and components (SSCs), including:

- facility foundation structures (including support pilings)
- facility intake and outlet channels and structures (including cooling ponds, cooling towers and related connections to the ultimate heat sink)
- non-nuclear facility SSCs, such as a plant water treatment plant, if it can be shown that the design of these systems will be independent of the reactor technology (or technologies) being considered and will be sufficient for any reactor technology proposed for the site

Selection of a specific facility technology is not required when submitting a licence to prepare site application, but the application must provide enough information to demonstrate that releases of nuclear and hazardous substances meet the bounds established in the EA and meet all applicable regulatory requirements. The Commission may issue a licence to prepare site with conditions that restrict activities to those that are not technology-dependent, until the applicant selects a facility technology.

Applications for a licence to prepare a site that are submitted without the selection of a specific facility technology should ensure that the bounding parameters encompass all technologies under consideration. In this case, the application should include all design information that is necessary

to support proposed site preparation activities (for example, plant footprint excavation, and excavation of cooling water intake tunnels).

In most cases, programs, processes and procedures developed at the licence to prepare site stage will continue to be used, and will be adapted to support future phases of the project (for example, facility construction and operation).

The applicant should also describe the process that will be followed if new information is acquired that may invalidate or cast doubt on information previously submitted to the CNSC.

Activities performed at this stage in the development of a future nuclear site are similar to those found at any large-scale construction/land development project; however, because the undertaking is a licensed activity under the *Nuclear Safety and Control Act* (NSCA), the applicant must clearly demonstrate the protection of health, safety, security and the environment. For this reason, in addition to the technical information describing the facility's design and physical layout, the applicant must address all of the CNSC's safety and control areas (SCAs) except human performance management, fitness for service, and packaging and transport as part of the application for a licence to prepare the site. (Note that, for site preparation, basic human performance management aspects are addressed under the management system SCA).

4.3 Management system

The management system shall have provisions for effective management of site characterization and evaluation, site preparation, design, construction, commissioning and technical support functions (including contractor management) being performed under the licence to prepare site so as to promote and assure safety.

Management system arrangements shall demonstrate adherence to CSA N286, *Management system requirements for nuclear facilities* [26], or equivalent standard established in the licensing basis, as applicable to the relative project phase.

The provisions of the management system extend to contracted workers (contractors) who are implementing activities under the oversight of the applicant organization.

In cases where there may be the need for early procurement of SSCs to accommodate early use or long (critical path) procurement spans (for example, long-lead items), the respective design and safety analysis, and supply chain programs, processes and procedures shall be in place.

Where the applicant plans for a different management system and organizational structure for the future construction and operation of the plant, the applicant shall provide overall arrangements (including those for the transition to construction to commissioning to ensure continuity).

The assessment of the results of the site evaluation is a key part of activities carried out under a licence to prepare site. The applicant shall describe the management system that governed the conduct of site evaluation activities (see section 3.8, Management system for site evaluation).

Guidance

This section should describe the applicant's management system being implemented for the management and control of all licensed activities. The description should demonstrate that appropriate provisions integrating safety, health, environmental protection, security, and quality have been implemented for all safety-related activities. This section should also describe

measures taken to ensure the implementation and observance of the management system programs, processes and procedures.

If external contractors are working onsite, the applicant's oversight of contractor activities should be documented, including:

- contractor's representatives performing site preparation activities, showing the line of accountability to the applicant's organization
- organization chart for the site activities for which the contractor is responsible
- contractor's level of authority for site activities
- oversight provisions by the applicant for the activities of the contractors

Provisions for an effective management system include:

- appropriate provisions for integrating safety, health, environmental protection, security, and quality for all site preparation activities, and for understanding and promoting a safety culture
- measures taken to ensure the implementation and observance of the management system programs, processes, procedures and practices
- provisions for personnel responsible for compliance to have direct access to senior levels of the applicant's management structure, to ensure that their needs and concerns receive adequate consideration
- a description of organizational structure; including authorities, accountabilities and responsibilities of positions; internal and external interfaces; and how and by whom decisions are made
- management system documentation that describes the corporate and site management structures of the applicant, of major technical support organizations, of the designer, and of major contractors and sub-contractors

For more information, see RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant* [32]; especially:

- the general considerations and the operations management processes for guidance on management system and management structure for future project steps
- section 8.3.1 for guidance on long-lead items

4.3.1 Human performance and safety culture

The management system sets expectations for, and supports, human performance and is instrumental in understanding and promoting a safety culture. It provides the means by which work is to be carried out safely and the processes to understand and improve the safety culture.

Safety culture is applicable to all the activities that may affect health, safety and the environment, and it applies to all personnel involved in every phase of the facility's lifecycle. A healthy safety culture in the site preparation phase increases confidence in the licensee's future performance in later licensing steps.

4.3.2 Management system for design activities during site preparation

At this stage in the project lifecycle, it is important to ensure that design activities are managed according to the design organization's management system for the reactor technologies under consideration. Design control measures, in the form of management system processes, procedures and practices, ensure consistent quality of the design of facility systems, structures and

components. High-quality design, and design management, serve to minimize latent design flaws that may manifest themselves as safety issues later in the facility's life.

Design includes and is not limited to:

- technical activities that start with the identification of conceptual input and that produce documentation
- process and the result of developing the concept, detailed plans, supporting calculations and specifications for a nuclear facility and its parts
- engineering/technical and safety analyses and assessments

Design management includes and is not limited to:

- demonstration of sufficient competent managerial and suitably qualified and experienced technical staff to carry out its safety functions, make safety judgments and to comply with any regulatory requirements
- demonstration of adequate control and supervision arrangements to ensure that the responsible authority is in control of its undertakings
- provisions to:
    - monitor performance, compliance, cultural attitudes and behaviours, and take appropriate action (monitoring may include audits, surveillance, surveys and participation in design verification activities)
    - determine that there are adequate numbers of suitably trained, qualified and experienced staff
    - verify that the technology, tools and methods used are proven and are established on the basis of best industry practice
    - assess the technical and safety assessment capabilities in the context of the reactor technology organization being an intelligent user of consortium members and subcontractors
    - ensure the product and/or work produced is of appropriate quality, through review and acceptance of engineering deliverables
    - understand the relevance of the product and/or work to the relevant safety case or safety cases

The process of establishing site evaluation-related management system parameters should involve technical and engineering analyses, along with judgments that require extensive experience and knowledge. In many cases, the parameters and analyses may not lend themselves to direct verification by inspections, tests, or other techniques that can be precisely defined and controlled. In these cases, evaluations should be reviewed and verified by individuals or groups who are independent of those who did the work.

Feedback associated with experienced engineering judgment and expertise in geotechnical engineering is an important aspect of assuring the quality of the site evaluation process. For example, in the assessment of matters such as liquefaction potential and slope stability, the accuracy of the evaluation results depends heavily on insight into failures that have occurred in comparable situations. The information gathered from these assessments should be documented and analyzed to provide evidence that similar failures should not occur.

4.3.3 Design of the nuclear facility - design control measures

The design programs, processes, procedures and practices for the selected facility technology shall satisfy the applicable criteria for management systems established in the licensing basis; for example (as applicable):

- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6]
  or
  RD-367, *Design of Small Reactor Facilities* [33]
- CSA N286, *Management system requirements for nuclear facilities* [26]

The design organization, if different than the applicant, shall have a management system compliant with the requirements in CSA N286. Where the applicant or reactor technology organization's design programs, processes procedures and practices are structured to standards other than CSA N286, the applicant shall demonstrate how these satisfy the applicable criteria of CSA N286.

Applicable portions of the management system shall be in place before any design activities are undertaken.

Guidance

The applicant should demonstrate that design organization's management system has been reviewed, adequately implemented and accepted.

4.3.4 Where a specific facility design has been selected

For reactor technologies under consideration whose design parameters are included in the application for a licence to prepare site, the design management system of the reactor vendor should be assessed to ensure it meets the requirements of CSA N286, *Management system requirements for nuclear facilities* [26].

4.3.5 When facility design selection is deferred

Guidance

In cases where the selection of a specific facility design is deferred, the management system should include:

- programs, processes, procedures, execution plans, and so on for the selected project execution model and contracting strategy
- a description of the organization, including:
  - interrelationships
  - areas of responsibility, including where the applicant retains and exercises overall project and management system responsibility; limits of authority; and boundaries between the applicant, designer (usually the design authority up to some point during facility construction and commissioning), major technical support organizations, constructor and consortium members, and major sub-contractors
- provisions for assuring effective management control has been and will continue to be exercised for the design (including the design authority), to promote and assure the safety aspects of work being performed
- provisions for assuring proper implementation and observance of the management system

4.4 Operating performance

For activities conducted under the licence to prepare site, the applicant shall characterize the risks to health, safety and the environment that may be encountered by workers and the public.

The applicant shall outline the strategy that the applicant will take (including development of mitigation measures) upon discovery of additional risks to the health and safety of the public that were not anticipated during the licence application process.

Guidance

These risks are generally similar to those encountered during pre-construction activities at a conventional large-scale construction project. Some examples are:

- noise hazards, primarily from blasting activities and operation of heavy machinery
- dust from overburden and rock removal and movement
- chemical hazards from fuel spills, and conventional chemicals used during the construction of non-nuclear plant structures
- mechanical hazards from excavation, earth movement, road building, and so on
- ground vibration and flying rock hazards from blasting activities
- electrical hazards from establishing construction electrical infrastructure

The applicant should assess risks to the health and safety of workers and the public resulting from the activities encompassed by the licence to prepare site. This assessment includes consideration of accidents and malfunctions that could occur during site preparation activities (including those that might originate from adjacent nuclear facilities, where applicable).

Where risks to the health and safety of either workers or the public could be higher than for a conventional project, the applicant should provide credible research supporting the potential consequences, and measures to mitigate the risks. For example, if site investigation has indicated the presence of a sub-surface hazardous substance, the applicant should provide an investigation of the effects of that substance, if unearthed, on the health and safety of workers and the local public.

For more information on radiation protection, see section 4.7.

4.5 Safety analysis

The applicant shall conduct a hazard analysis focusing on activities under this licence. For information to support the hazard analysis, see sections 4.8, Conventional health and safety and 4.9, Environmental protection.

4.6 Physical design

As explained in appendix A, the applicant is required to provide certain information based on their decision for an exclusion zone. The following subsections provide information on how the applicant may decide on the proposed boundaries for this zone.

An exclusion zone is a parcel of land within or surrounding a nuclear facility on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control [9].

Physical design also applies to safety-important civil work and to the layout of areas, structures and systems.

4.6.1 Exclusion zone and emergency planning zones

The applicant shall provide information on the proposed exclusion zone (including size and boundary) and on the proposed emergency planning zones. For more information on considerations, see section 3.3.5.

Whether the technology has been chosen or not, the exclusion zone size is characterized based on a combination of dose limits, security and robustness design considerations, meteorological conditions and emergency preparedness considerations that are affected by the land use around the site. The applicant shall consider the following criteria (for an operating unit) in determining the size of the proposed exclusion zone:

- committed whole-body dose for average members of the critical groups who are most at risk at or beyond the exclusion zone boundary, is calculated in the deterministic safety analysis for a period of 30 days after the analyzed event
- under normal operating conditions, the effective dose at the exclusion zone boundary to a person who is not a nuclear energy worker shall not exceed 1 mSv over the period of one calendar year
- under anticipated operational occurrence (AOO) conditions, the effective dose at the exclusion zone boundary to a person who is not a nuclear energy worker shall not exceed 0.5 mSv over the release time due to the AOO
- under design-basis accident (DBA) conditions, the effective dose at the exclusion zone boundary to a person who is not a nuclear energy worker shall not exceed 20 mSv over the release time due to the DBA
- demonstration that the dispersion model used for the dose calculations is representative of the actual site

The applicant may use either of two acceptable approaches in determining the location of the exclusion zone boundary. Both approaches (described below) use site characterization information from the site evaluation.

For more information, see CSA N288.2, *Guidelines for calculating the radiological consequences to the public of a release of airborne radioactive material for nuclear reactor accidents* [34].

Approach 1: Simplified exclusion boundary case

A specific distance for the boundary from the facility may be selected, based on predicted bounding values for radiological dose and exposures to hazardous substances (along with assumptions of facility robustness and emergency preparedness capabilities of the site and surrounding area). Key considerations are:

- this approach requires only high-level design information for the types of facilities being considered
- if assumptions are correct, the boundary location will be conservatively located and will maximize options for locating structures on the site
- the site footprint may be larger than that used for approach 2

There may be implications for the construction and operations phases. At a later licensing stage, it may be determined that the exclusion zone boundary is too close to the facility, or the assumptions regarding releases to the environment during normal and accident conditions are not

met. Mitigating actions may be required; these actions could include facility design changes or changes to the facility's operating parameters. An extension of the exclusion zone boundary later in the licensing process would likely involve significant regulatory reviews, because of the relationship between the exclusion zone boundary and technical areas such as security and emergency preparedness.

Approach 2: Comprehensive exclusion boundary case

Using a systematic process, a detailed case is developed for the exclusion zone boundary location, based on predicted values for radiological dose and exposures to hazardous substances (along with assumptions of facility robustness and emergency preparedness capabilities of the site and surrounding area). Key considerations are:

- there is greater certainty that the design(s) proposed for the site will not require extensive design changes to meet exclusion zone radiological dose and hazardous substances exposures criteria
- the site footprint is optimized from the onset of the project
- a detailed exclusion zone case must rely on detailed facility design information; for example:
  - descriptions of all major SSCs that could significantly influence the course or consequences of principal types of accidents and malfunctions
  - implications for emergency preparedness based on the physical layout of the facility
  - security considerations

  For more information, see sections 3.3.4 and 3.3.5.

Emergency planning zones

The applicant is required to provide certain information about the emergency planning zones. For more information, see section 3.3.5.

4.6.2 Civil structures and civil works

As pertaining to the licence to prepare site, the application shall include information on the design measures such as flood protection and erosion control.

Guidance

The application should also provide information on any safety-important civil work carried out during site preparation and on civil structures used in site preparation (for example, containment dykes, retaining walls, earthworks).

4.6.3 Layout of areas, structures and systems

The applicant shall present the proposed layout of structures in the final layout state (to the extent practicable).

For each proposed plant design and proposed layout(s) of areas, structures and systems of the nuclear facility (or facilities), the applicant shall provide:

- satellite or aerial photographs of the site and surrounding region, with a resolution scale of 1:1,440 or better, including the proposed exclusion zone and site boundary
- topographical map(s) for each site layout in 1:50,000 to no smaller than 1:250,000 scale for all structures and associated infrastructure (all drawings are to scale and include a legend)
- proposed layouts of labelled structures, including:

  - reactor building
  - turbine-generator block
  - auxiliary power buildings (for example, diesel generators) and related fuel storage
  - switchyard
  - cooling tower structures, water intakes and outlets
  - large structures (for example, machine shops or storage buildings for parts inventory) in the immediate vicinity to the proposed nuclear facility
- proposed conventional and radiological waste transfer and storage areas
- layouts of all site roads and proposed transmission corridors
- locations of transportation corridors in the vicinity of the site (for example, rail lines, shipping lanes, roads, proximity to airports)

Guidance

Map and photograph resolution criteria are not considered to be prescribed information under the NSCA. The resolution scales listed above provide sufficient detail for review of the proposed layout(s) of the nuclear facility (or facilities).

4.7 Radiation protection measures

The applicant shall assess the doses to workers associated with activities to be encompassed by the licence to prepare site, or from exposures to any radioactive substances resulting from past or present nuclear activities (for example, discovery of contaminated soils during excavation).

The dose assessment shall demonstrate that the predicted annual effective dose, including the committed effective dose associated with annual intakes of radionuclides, to workers during site preparation will:

- not exceed the applicable dose limits of the Radiation Protection Regulations
- be as low as reasonably achievable (ALARA), social and economic factors taken into account

The applicant shall consider any associated mitigation measures that are technically and economically feasible. In particular, the applicant shall identify engineering controls to be applied to reduce the magnitude of each source, and work practices aimed at controlling radiation exposure of workers; and shall adopt mitigation measures as appropriate.

Guidance

The radiation protection measures should address the information provided in section 11 of RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant* [32] and should be commensurate with the hazards that may be encountered.

4.8 Conventional health and safety

The production and use of nuclear energy is under federal jurisdiction. When in the presence of a federal undertaking, and integral to the operation and management of that undertaking, the labour relations and working conditions – which includes occupational health and safety (OHS) – also fall under federal jurisdiction.

The regulation of OHS in nuclear power plants may involve three regulatory agencies:

- Employment and Social Development Canada (ESDC)
- the provincial ministry of labour where the site is located

- the CNSC

The applicant shall develop, implement and maintain occupational health and safety (OHS) programs to prevent occupational injuries and illnesses.

The applicant shall identify OHS hazards, assess the associated risks, and ensure the necessary materials, equipment, programs and measures are put in place to effectively manage, control and minimize those risks.

The applicant shall ensure the OHS policies and procedures of the applicant and of all contractors engaged by the applicant for purposes of site preparation comply with the applicable provincial/territorial requirements.

Guidance

Governance of OHS matters is determined by analyzing and identifying the applicable jurisdiction for each case. OHS matters at nuclear facilities usually fall under the responsibility of the Labour Program at ESDC, but licensee organizations in certain provinces be governed by provincial laws. This excludes federal jurisdiction over OHS matters at nuclear facilities that are operated by provincial crown corporations.

For provinces and territories where the governance over OHS matters has not been formally assigned by law, jurisdiction and governance over OHS issues remain with ESDC and the *Canada Labour Code, Part II*.

The applicant's health and safety organization shall:
- be qualified and make adequate provision for the protection of the health and safety of persons
- meet the requirements in the applicable provincial or federal codes
- adequately execute the proposed worker health and safety policies and procedures described in this regulatory document; for example:
  - demonstrating adequate oversight of the site OHS program
  - ensuring compliance with applicable OHS regulations and requirements
  - ensuring adequate OHS training of persons involved in site preparation activities
- having capabilities for reporting and investigation of incidents and significant events

4.9 Environmental protection

For reactor facilities, environmental protection includes requirements in addition to REGDOC-2.9.1, *Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2].

Applicants for a licence to prepare site must also:
- describe the protection measures for accidents and malfunctions that may occur during site preparation
- fully demonstrate that they meet the requirements of:
  - CAN/CSA-ISO 14001, *Environmental management systems – Requirements with guidance for use* (2004 edition or successor editions) [35]
  - CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [36]

- CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
- CSA N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [37]
- CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]
- CSA N288.7, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* [38]
- CSA N288.8, *Establishing and implementing action levels for releases to the environment from nuclear facilities* [39]

4.9.1 General considerations for environmental protection

The applicant shall demonstrate that all reasonable precautions are being taken to control and monitor the release of nuclear substances or hazardous substances to the environment resulting from site preparation activities and ensure that licence limits are being respected.

The applicant shall demonstrate that the proposed environmental protection policies, programs and procedures needed for the subsequent licensing phases have been established.

All applications for new reactor facilities shall include an environmental risk assessment (ERA). For more information, see REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1 [2].

As described in REGDOC-2.9.1 and as applicable to site preparation activities, the applicant shall describe the proposed:

- effluent and emissions control and monitoring measures
- environmental monitoring measures
- groundwater protection and monitoring measures
- environmental management system

Guidance

For site preparation, environmental monitoring consists of defining baseline characteristics and monitoring the effects of site preparation activities on the environment.

As applicable to site preparation activities, the environmental protection measures should also address:

- CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [36]
- CSA N288.2, *Guidelines for calculating the radiological consequences to the public of a release of airborne radioactive material for nuclear reactor accidents* [34]
- CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]
- CNSC, G-228, *Developing and Using Action Levels* [40]
- IAEA Safety Guide No. WS-G-2.3, *Regulatory Control of Radioactive Discharges to the Environment* [41]

4.9.2 Performance of site preparation and facility construction by different organizations

Where the applicant plans to proceed with site preparation using another organization until the selection of a reactor technology and a contract is in place, the applicant shall provide information that demonstrates that the contractor organization has the capability to design environmental measures.

Guidance

Examples of environmental measures that may be carried out by contractors include the design of flood protection and erosion control, and of adequately supporting structures and civil works.

4.9.3 Protection of people

The applicant shall assess the doses to the public associated with activities to be encompassed by the licence to prepare site, or from exposures to any radioactive substances resulting from past or present nuclear activities (for example, discovery of contaminated soils during excavation).

The dose assessment shall demonstrate that the predicted annual effective dose, including the committed effective dose associated with annual intakes of radionuclides, to the public during site preparation will:

- not exceed the applicable dose limits of the *Radiation Protection Regulations*
- be as low as reasonably achievable (ALARA), social and economic factors taken into account

The applicant shall consider any associated mitigation measures that are technically and economically feasible. In particular, the applicant shall identify engineering controls to be applied to reduce the magnitude of each source, and shall adopt mitigation measures as appropriate.

4.10 Emergency management and fire protection

An emergency response plan is required for the licence to prepare the site to ensure that adequate and timely emergency assistance is available to protect workers, the public and the integrity of site security, while mitigating adverse environmental effects during project activities.

All aspects of the emergency preparedness program should be commensurate with the hazards on the licensed site.

Where emergency response resources are shared between the site and other nearby nuclear facilities, the applicant shall demonstrate that the site will maintain sufficient complement to adequately address emergency response needs.

The applicant shall ensure that the emergency preparedness program maintains an adequate response capability to respond to and mitigate the emergency situations that could occur at the site, including malevolent acts, accidents and malfunctions for the site preparation phase.

The applicant shall provide details of the site emergency response organizations of the applicant and other applicable organizations, including the numbers and positions of all site staff who are assigned to emergency response duties.

Guidance

Although hazards of a malevolent nature are not described in this section of the licence application, the applicant should consider the emergency response to those hazards; note that the effects of such hazards are likely to be similar to those of conventional accidents and malfunctions.

The program should contain the following elements:

- a training program for emergency response personnel, commensurate with evolving hazards at the site
- a site hazard change program that, when implemented, can inform emergency preparedness staff of changing hazards on the licensed site to maintain adequate emergency response capability for all potential accident situations (note that a sufficient notification process should be implemented to allow emergency response organizations to adequately prepare prior to the introduction of new hazards on the licensed site)

For more information on a proposed nuclear emergency preparedness program and response plan, as applicable for site preparation, see:

- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, Version 2 [10]
- CSA N1600, *General requirements for nuclear emergency management programs* [42]
- IAEA GS-R-2, *Preparedness and Response for a Nuclear or Radiological Emergency* [43]

4.11 Waste management

Waste management includes both nuclear and hazardous substances [9] that are used or produced in the course of carrying on a licensed activity and that may pose a risk to the environment or the health and safety of persons."

For site preparation, the applicant should consider how to manage existing onsite hazardous substances that are identified during site evaluation, as well as the hazardous substances that will be produced during activities encompassed by the licence to prepare site.

4.11.1 Hazardous substances and hazardous wastes

The applicant shall address:

- quantities and physical characteristics (including hazards posed to health and safety) of each substance or waste, including by-products
- for all substances or by-products that are regulated or controlled, the appropriate list of regulations governing their control
- transport, storage and use of hazardous substances
- processing and disposing of hazardous wastes

Guidance

The applicant should characterize all hazardous substances and hazardous wastes in a list as follows:

- name of hazardous substance or hazardous waste
- origin of hazardous substance or hazardous waste
- possible by-products that could evolve from:
  - the hazardous substance or hazardous waste,

  - any interactions between the hazardous substances or hazardous wastes, or between the possible by-products
- anticipated quantity or volume, and anticipated form
- hazards to workers and the public who may be exposed to the hazardous substance, hazardous waste or by-products
- how the hazardous substance, hazardous waste or by-products will be processed or disposed of at the site

4.11.2 Decommissioning

At site preparation, the applicant shall consider two areas of decommissioning:

- **site evaluation from a decommissioning perspective:** the applicant shall demonstrate that the site evaluation process:
  - has appropriately considered future decommissioning in the planning for the nuclear facility
  - has adequately considered end-of-life decommissioning
- **activities encompassed by the licence to prepare site:** a preliminary decommissioning plan and financial guarantee that cover the scope of work and related costs to return the site from the conditions expected at the end of a licence to prepare site to an agreed-upon end state (including, if the project is halted, restoration of the site to the original condition)

Guidance

An adequate preliminary decommissioning plan ensures that the cost estimate associated with the financial guarantee can adequately decommission the facility to an acceptable end-state condition. **Note:** In this context, "facility" refers to the site encompassed by the licence to prepare site, and "end-state condition" refers to the expected state at the end of completion of site preparation activities.

For more information, refer to:

- G-219, *Decommissioning Planning for Licensed Activities* [27]
- CSA N294, *Decommissioning of facilities containing nuclear substances* [28]

4.12 Security

At the site preparation stage, the security program is primarily focused on protection of prescribed information. The security program is developed in view of the project progressing to the construction stage.

Applicant submissions and resultant review correspondence related to security is considered to be prescribed information [9] under the NSCA and is submitted in a secure manner. Prescribed equipment [9] is not expected to be part of a licence to prepare site.

The quantity of prescribed information to be encompassed by the licence to prepare site is small and the scale of the program should be commensurate with the quantity and nature of the information.

Some examples of prescribed information are:

- security threat and risk assessments
- electronic data/communications and/or written records
- security arrangements

- security equipment
- security systems
- security procedures established by the applicant, including any details around the management of records related to security incidents
- the proposed measures to control access to the site, including proposed measures to prevent loss or illegal use of information relating to security

In an effective screening criteria process for the position of nuclear security officer, the physical, medical and psychological requirements (based on a physical demands analysis) are part of the job description (for example, performing foot/vehicle patrols, detaining unarmed intruders, comprehending procedures and successfully completing assigned tasks). The site-specific criteria for assessing physical, medical and psychological fitness associated to training and in performing assigned duties should be included as screening criteria for security officer positions.

4.12.1 General consideration for security

The security measures shall provide oversight, management and control, with documented policies and procedures.

The applicant's security measures shall address the following elements:
- prescribed information
- site security program
- site access clearance
- security arrangements with offsite response forces
- physical security
- cyber security
- security program officer

Guidance

The security measures should include:
- the proposed structure and organization of the security officer service, including the duties, responsibilities and training of security officers
- a description of the site security policy, including a list of reference documents that demonstrates that the security quality assurance criteria:
  - are integrated into overall quality assurance
  - meet applicable requirements of the management system established in the licensing basis such as CSA N286, *Management system requirements for nuclear facilities* [26]
  - use a graded approach
  - take into account the increasing complexity of the project as it evolves
- a demonstration that the proposed security measures have considered the applicable quality assurance criteria contained in ISO 27002:2013, *Information Technology – Security Techniques – Code of Practice for Information Security Controls*
- a description of security measures, procedures and processes that ensure that the required quality is defined and consistently achieved within the applicant's security policy
- documentation of how site personnel will be trained in security (high-level training strategy), measured and maintained, including measures to ensure that all security personnel are skilled, knowledgeable and accountable in performing assigned tasks and responsibilities

- information on the security system and subsystem availability program, including provisions for documentation and archiving, and maintaining records of functional testing and routine field testing

4.12.2 Prescribed information

The security program shall include an inventory change control process for prescribed information.

Guidance

The applicant's submission should include a description of adequate processes (including management system or quality assurance) to provide for adequate management of any changes to the prescribed information description.

4.12.3 Site security measures

The security measures shall:

- be based on risk/vulnerabilities and consider applicable criteria contained in G-274, *Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities* [44]
- have a site plan that conforms to section 16 of the *Nuclear Security Regulations*
- contain adequate criteria for the classification of prescribed information; electronic and hard copy information that discusses security risks, vulnerabilities, and strategies may require a higher classification pursuant to the Government of Canada Treasury Board's *Policy on Government Security* [45]
- describe the procedures for reporting events internally and to the CNSC
- be implemented according to the applicant's established quality assurance program
- have a configuration management program for physical assets and "soft" assets, such as information technology and records
- have an adequate skills (training) program, with a particular focus on staff who maintain cybersecurity and network security
- have fitness-for-duty criteria (for more information, see REGDOC-2.2.4, Fitness for Duty, Volume I: Managing Worker Fatigue [46] and REGDOC-2.2.4, Fitness for Duty, Volume II: Managing Alcohol and Drug Use [47])
- have processes to examine, assess and implement lessons learned from similar projects and industry operational experience

4.12.4 Site access clearance

For administrative processes and physical assets used in the security program, the applicant should ensure that the effectiveness of the security mitigation measures is maintained, and that the security measures meet the changing security needs due to "new" threats, risks and vulnerabilities.

The security measures shall describe the process for issuing an authorization for a site access clearance. An authorization for a site-access clearance is required for security staff and security support persons, including individuals requiring unescorted access to areas and processes where prescribed information is stored or used. The security measures shall contain procedures by which to adequately maintain staff security clearances.

The security measures shall also contain procedures for ensuring the security of persons who may not have a site access clearance but have a valid reason to enter a location containing the prescribed information. Typically, this is accomplished through the provision of an escort at all times.

For more information, see REGDOC-2.12.2, *Site Access Security Clearance* [48].

4.12.5 Security arrangements with offsite response forces

The security measures shall describe the communication protocols and processes for:

- effective consultation between the applicant and the offsite response force regarding the arrangements
- ensuring that the necessary resources are available
- listing the equipment available to the applicant and the offsite response force
- any other matter relating to the security of the facility

The applicant shall describe offsite communications equipment, systems and procedures. Where offsite response force capability is required, the applicant shall describe arrangements that demonstrate the offsite response force can respond or support the onsite security response force in making an effective intervention when requested. Where an offsite response force is integrated into the security program, the security program shall contain plans for annual familiarization visits to the facility by members of an offsite response force.

Written arrangements (for example, memorandum of understanding or other such agreement) with the offsite response force shall consider response time to an incident. If the response time is not reasonable, the applicant shall describe additional controls (for example, alarms or remote surveillance) to ensure the offsite response force has sufficient time for an effective intervention.

Guidance

Written arrangements should also consider other emergency response requirements of the response force (for example, natural disasters) and specific training limitations of the members of the force. Response-time analysis should be clearly presented and credible for the environmental conditions of the site and the capabilities of the offsite response force (for example, weather, geography, layout of roads, and recall time for off-duty staff).

4.12.6 Physical security

The applicant shall consider security measures relating to detection, delay and response to security events. Security measures should address adverse weather conditions that could impede the effectiveness of the measures (for example, heavy snowfall preventing security patrols, response and police response from offsite, detection device operability in areas where ice build-up is problematic).

As per section 21 to 23 of the *General Nuclear Safety and Control Regulations*, the applicant shall provide physical protection measures to control access to prescribed information, and to prevent loss, illegal use, illegal possession or illegal removal of such prescribed information. This information shall be managed on a "need to know" basis.

Security system devices shall meet the requirements contained in:

- RD-321, *Criteria for Physical Protection Systems and Devices at High-Security Sites* [49]

- RD-361, *Criteria for Explosive Substance Detection, X-ray Imaging, and Metal Detection Devices at High-Security Sites* [50]

Guidance

The applicant should describe onsite communications equipment, systems and procedures. Security measures should give special consideration to prescribed information assets stored outside, even temporarily.

4.12.7 Cyber security

The applicant shall provide a cyber security policy that considers risks and vulnerabilities identified in the site selection threat and risk assessment (SSTRA), and that defines the objectives and elements of the cyber security program.

Guidance

The applicant should define operational procedures, including high-level technical requirements for protecting prescribed assets from a cyber attack.

The cyber security element of the security program should consider the information in CSA N290.7, *Cyber Security for Nuclear Power Plants and Small Reactor Facilities* [51].

4.12.8 Security officer program

The applicant shall ensure that the security officer program meets the requirements in RD-363, *Nuclear Security Officer Medical, Physical and Psychological Fitness Training* [52]. The skills management program for security officers should ensure the necessary skills and knowledge are maintained to accomplish the assigned duties and tasks.

4.13 Safeguards and non-proliferation

Canada has adopted both the international protocol for safeguards (IAEA INFCIRC/164, *Agreement between Government of Canada and IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* [53]) and the additional protocol (IAEA INFCIRC/164/Add.1, *Protocol additional to INFCIRC/164* [54]), which prevents unauthorized sharing of information such as for detailed designs.

The applicant shall provide a description of the arrangements made by the applicant, as applicable to site preparation, that will permit the CNSC to discharge Canada's obligations and provide information to the IAEA. The application shall describe how the arrangements address the requirements in REGDOC-2.13.2, *Import and Export* [55] and RD-336, *Accounting and Reporting of Nuclear Material* [56].

The applicant should describe measures related to site buildings and structures, operational parameters and the flow and storage of nuclear material, from the facility's design phase through to its decommissioning and eventual abandonment.

The application should describe how the program ensures that the IAEA is able, upon request, to access the facility for inspections and other verification activities.

4.14 Other matters of regulatory interest

The applicant shall address other matters of regulatory interest, including public information and disclosure; Aboriginal engagement; intergovernmental consultation; and financial guarantees.

4.14.1 Public information and disclosure program

The applicant shall describe how their proposed public information and disclosure program (required by all licensees) meets the requirements in RD/GD-99.3, *Public Information and Disclosure* [4].

The description shall include how and with what tools the licensee will communicate with the public, particularly with those persons living in the vicinity of the site, and the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the operation of the facility (listed under "General Requirements for Licence Applications" under section 3(j) of the *Class I Nuclear Facilities Regulations*).

Guidance

The applicant should initiate the public information program well ahead of their application for a licence to prepare site.

4.14.2 Aboriginal engagement

The CNSC, as an agent of the Crown, has the responsibility to ensure that Canada's legal obligations to Canada's Aboriginal peoples, as outlined in section 35 of the *Constitution Act, 1982*, are respected. Applicants and licensees' Aboriginal engagement activities help inform the CNSC's approach to Aboriginal consultation.

REGDOC-3.2.2, *Aboriginal Engagement* [5] sets out requirements and guidance for licensees whose proposed projects may raise the Crown's duty to consult.

4.14.3 Intergovernmental consultation

Guidance

The applicant should provide a summary of the results of consultation with all levels of government, to indicate their intended involvement and support for the project.

Federal consultation should include any consultation with other national governments, if the proposed project may have interfaces with or potential environmental effects on jurisdictions outside Canada.

The summary should provide an overview of any outstanding issues resulting from consultations that must be resolved before the project can proceed.

4.14.4 Financial guarantees

The applicant shall provide financial guarantees for restoration of the site should the project be discontinued. The amount of the proposed financial guarantee shall be sufficient to complete all site decommissioning activities that are described in the preliminary decommissioning plan.

For more information, see G-206, *Financial Guarantees for the Decommissioning of Licensed Activities* [57].

Guidance

The applicant is not required to provide a financial guarantee for complete decommissioning of the future reactor facility until submitting an application for a licence to construct the facility.

The financial guarantee should be in proportion to the outstanding liabilities for decommissioning and related activities needed to complete the decommissioning plan.

Appendix A: Licence Application Guide: Licence to Prepare Site

By following the information in this licence application guide, applicants will submit the appropriate information to demonstrate that they are qualified and will make adequate and reasonable provisions to undertake the activity to be licensed.

The licence application for a licence to prepare site shall include the following information to satisfy the requirements of the *Nuclear Safety and Control Act* (NSCA) and the regulations made under the NSCA. The applicant may identify appropriate information and documents as being subject to confidentiality requirements.

CNSC staff will review the application and the supporting documentation, and assess whether the information is acceptable. CNSC staff review the activities proposed by the applicant, taking into account:

- potential interactions between the facility or activity and the environment
- where appropriate, sufficient facility design information has been supplied to support the proposed site preparation activity (for example, facility "footprint" excavation, cooling water intake)
- sufficient site characterization and site evaluation information has been provided to demonstrate that the site is suitable for construction and operation of the reactor facility
- activities are controlled/undertaken to adequately to protect the health and safety of persons, the environment, and meet international obligations
- the financial guarantee under the licence to prepare site adequately addresses restoration of the site required as a result of the proposed activities, should the project be abandoned
- adequate oversight will be in place during execution of activities, to ensure compliance with the NSCA and its associated regulations

When the Commission grants a licence, the information describing the safety and control measures will form part of the licensing basis.

Note 1: The applicant may choose to organize the information in any structure. However, the applicant is encouraged to organize the licence application according to the CNSC's Safety and Control Area (SCA) framework.

Note 2: As described in section 2, the assessment of the results of the site evaluation is a key part of the activities carried out under a licence to prepare site.

Note 3: As stated in section 2, the Commission will not grant a licence until the environmental assessment (EA) is complete.

A.1 General considerations

The application may be completed in either of Canada's official languages (English or French).

The applicant is responsible for ensuring that the licence application contains sufficient information to meet regulatory requirements and to demonstrate that the applicant is qualified to carry on the licensed activity and will make adequate provisions to protect the health, safety and security of persons and the environment. If some information requested in various sections is redundant, the applicant may provide cross-references to detailed information in other sections as appropriate.

The applicant should ensure that the application is complete, dated and signed by the appropriate authority, and that all supporting documents are clearly identified and cross-referenced. All information submitted is subject to the provisions of the *Access to Information Act* and the *Privacy Act*. It is the

applicant's responsibility to identify and justify any material that is not suitable for disclosure (that is, subject to confidentiality requirements). Submitted information may be presented to the Commission to support the licensing decision. Any such information is also made available to the public on request, subject to confidentiality requirements.

Applicants are strongly encouraged to submit the documents in electronic format (for example, on secure memory devices). The applicant may choose, instead, to submit the licence application in printed (hard-copy) format. In this case, the applicant should submit two printed copies of the application (signed and dated) to the Commission at:

Commission Registrar
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
280 Slater Street
Ottawa, ON K1P 5S9

As required by section 27 of the *General Nuclear Safety and Control Regulations*, the applicant shall keep a record of all information relating to the licence that is submitted by the applicant to the Commission.

Note that prescribed information, such as details of the security program, may be transmitted only by secure means, such as letter mail or encrypted secure memory devices. It is prohibited to submit prescribed information via unencrypted email. Guidance for the protection and transmission of prescribed information can be found in REGDOC-2.12.3, *Security of Nuclear Substances: Sealed Sources* [58].

The applicant may submit a complete application or a partial application. For a partial application, the applicant should include the following information:

- applicant's general information and general project information (sections A.3 through A.5)
- a schedule for submission of the remaining material
- the intended approach for the conduct of the EA and licensing process (that is, parallel or sequential approach); see REGDOC 2.9.1, *Environmental Protection: Environmental Principles, Assessment and Protection Measures*, Version 1.1 [2]

A.2 Structure and organization of the information in the licence application

The applicant may choose to organize the information in any structure. However, the applicant is encouraged to organize the licence application according to the CNSC's SCA framework so as to facilitate the CNSC's review. If the application does not follow the order and organization of SCAs as shown in this licence application guide, the applicant should map the application to the CNSC's SCA framework.

The CNSC uses SCAs as the technical topics to assess, review, verify and report on regulatory requirements and performance across all regulated facilities and activities, as follows:

- management system
- human performance management (not applicable for a licence to prepare site)
- operating performance
- safety analysis
- physical design
- fitness for service (not applicable for a licence to prepare site)
- radiation protection
- conventional health and safety

- environmental protection
- emergency management and fire protection
- waste management
- security
- safeguards and non-proliferation
- packaging and transport (not applicable for a licence to prepare site)

In addition, the applicant's licence application must address reporting requirements, public and Aboriginal engagement, and financial guarantees.

A.3 Applicant's General Information

Applicable regulatory basis:
- *Nuclear Safety and Control Act*, paragraph 24(4)(a)
- *General Nuclear Safety and Control Regulations*, paragraphs 3(1)(a) and 15(a), (b) and (c)
- *Class I Nuclear Facilities Regulations*, paragraph 3(c)

A.3.1 Applicant's name and business address

The applicant shall provide the applicant's name and business address.

The name should be that of the persons or organization applying for the licence, as it appears on the proof of legal status documentation (such as the proof of incorporation or sole proprietorship). The applicant should name an individual only if that person is a sole proprietor or will be solely responsible for the licence.

The business address should be the legal, physical address of the applicant's head office, including the complete street name and number, rural route number if appropriate, city, province or territory, and postal code. A post office box number is not acceptable for a head office address.

The applicant should notify the Commission within 15 days of any changes to this information.

A.3.2 Mailing address

If the mailing address is different from the head office address, the applicant should provide the mailing address, including the complete street name and number, rural route number if appropriate, city, province or territory, and postal code.

If no address is provided here, the licence issued in response to the application will be mailed to the head office address. A post office box number is acceptable as a mailing address.

The applicant should notify the Commission within 15 days of any changes to this information.

A.3.3 All persons who have authority to interact for the applicant with the CNSC

The applicant shall notify the Commission of the persons who have authority to act for them in their dealings with the Commission. Also, the applicant shall notify the Commission of any change in the information, within 15 days after the change occurs.

The applicant should provide a list of names, positions and contact information of all persons who are authorized by the applicant to interact with the CNSC. **Note:** The applicant may request that, for security reasons, this information be subject to confidentiality requirements.

A.3.4 Proof of legal status

First-time applicants should provide proof of legal status by appending proof of incorporation, corporation number or charter. When submitting an application to renew a licence, proof of legal status should be provided if the applicant's original organization name has changed.

If the applicant is a corporation, the application should include the following information:
- corporation's legal name
- corporation number
- date of incorporation
- registered office address (if different from the head office address)

A.3.5 Evidence that the applicant is the owner of the site or has authority from the owner of the site to carry on the activity to be licensed

The applicant shall provide evidence that the applicant is the owner of the site or has authority from the owner of the site to carry on the activity to be licensed.

A.3.6 Identification of persons responsible for management and control of the licensed activity

The application shall contain the applicant's organizational management structure insofar as it may bear on the applicant's compliance with the NSCA and the regulations made under it, including the internal allocation of functions, responsibilities and authority.

The applicant shall notify the Commission of the names and position titles of the persons who are responsible for the management and control of the licensed activity and the nuclear substance, nuclear facility, prescribed equipment or prescribed information encompassed by the licence. The applicant shall notify the Commission of any change in this information within 15 days after the change occurs.

To satisfy these requirements, the applicant should provide a summary list of all persons responsible for management and control of the licensed activity, including:
- names
- positions (job titles)
- contact information (email, telephone, facsimile)
- mailing addresses (if different from the business mailing address); include the complete street name and number, rural route number if appropriate, city, province or territory, and postal code

A.3.7 Billing contact person

The applicant should provide the following information for the person responsible for licence fee payments:
- name
- position
- contact information (email, telephone, fax)
- mailing address (if different from the business mailing address); include the complete street name and number, rural route number if appropriate, city, province or territory, and postal code

A.3.8 Legal signing authority

The applicant should provide the name, title and contact information (address, email address and telephone number) of the individual who is signing the application as the applicant authority.

By signing, the applicant authority is indicating that they understand that all statements and representations made in the application and on supplementary pages are binding on the applicant.

A.3.9 Nuclear and hazardous substances

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraph 3(1)(c)
- *Nuclear Substance and Radiation Devices Regulations*

For any activities that may use nuclear or hazardous substances during site preparation activities, and that are not exempt from a licence by the *Nuclear Substance and Radiation Devices Regulations*, the applicant shall state whether the substances will be encompassed by their own CNSC nuclear substance and device licences, or encompassed by the licence to prepare site.

Any activities using nuclear or hazardous substances outside of the licence to prepare site must be covered by a separate licence.

A.4 General description of the project

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraph 3(1)(b), 3(1)(d)

A.4.1 Activity to be licensed

The activity to be licensed is site preparation; that is, preparing a site for the construction and long-term operation of a nuclear power plant (or small reactor facility), followed by the eventual decommissioning and abandonment of the site.

A.4.2 Descriptive overview

The applicant shall describe the purpose of the facility (for example, for electrical power or to generate steam for industrial purposes) and shall provide total facility capacity, in Megawatts thermal (MWth), and/or Megawatts electric (MWe); for example, the total number of nuclear units and the projected in-service dates for each unit.

If site preparation activities involve construction of non-nuclear facility structures, systems and components (SSCs), the applicant shall provide technical information that demonstrates that these SSCs are appropriate for any reactor technology proposed for the site. Some examples of such SSCs are water treatment plants, excavation (that is, earthen structures) and condenser cooling structures.

Guidance

The applicant should clearly itemize all high-level activities proposed to be conducted under the licence to prepare site.

An application considering several technologies should clearly identify those site activities proposed to be undertaken under a licence to prepare site that are not affected by the technology choice, as well as those that are.

A.5 Location and site layout

The applicant shall provide an overview or summary of the location and site layout:

- a labelled map or series of maps showing the project's location
- a map of the site with the proposed or final layout locations (if possible) of the proposed structures determined for the site at the post-construction stage

A.6 Safety and Control Measures

The applicant's safety and control measures shall address all relevant clauses in the NSCA and the regulations made under the NSCA, and shall also address the relevant SCAs from the CNSC's SCA framework.

For each SCA, the applicant shall address the information described in section 4, to the level of detail and the specific considerations relative to the design of the proposed reactor facility. The applicant should also address the associated guidance, relative to the design of the proposed reactor facility.

Note: The following SCAs are not relevant to a licence application for a licence to prepare a site: human performance management, fitness for service, and packaging and transport.

A.6.1 Management system

The management system SCA covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against those objectives, and fosters a healthy safety culture.

Applicable regulatory basis:

- *General Nuclear Safety and Control Regulations*, paragraphs 3(1)(i) and (k) and 12(1)(a) through (j)
- *Class I Nuclear Facilities Regulations*, paragraphs 3(d) and 4(d)

A.6.2 Operating performance

The operating performance SCA includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.

Applicable regulatory basis:

- *Class I Nuclear Facilities Regulations*, paragraphs 3(c), 4(a) and 4(e)

A.6.3 Safety analysis

The safety analysis SCA covers maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventive measures and strategies in reducing the effects of such hazards.

Applicable regulatory basis:

- *Class I Nuclear Facilities Regulations*, paragraph 4(e)

A.6.4 Physical design

The physical design SCA relates to activities that affect the ability of SSCs to meet and maintain their design basis, given new information arising over time and taking changes in the external environment into account.

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraph 3(1)(d)
- *Class I Nuclear Facilities Regulations*, paragraphs 3(a), (b) and (j)
- *Nuclear Security Regulations*, paragraph 3(b)

A.6.5 Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the Radiation Protection Regulations. This program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA).

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraphs 3(1)(e), 3(1)(f), 29(1)(b), 17(d) and 17(e)
- *Class I Nuclear Facilities Regulations*, paragraph 3(g)
- *Radiation Protection Regulations*

A.6.6 Conventional health and safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

Applicable regulatory basis:
- *Class I Nuclear Facilities Regulations*, paragraphs 3(f) and 4(e)

A.6.7 Environmental protection

The environmental protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraphs 12(1)(c) and 12(1)(f)
- *Class I Nuclear Facilities Regulations*, paragraphs 3(a), 3(b), 3(c), 3(e), 3(g), 3(h), 3(j), 4(a), 4(b), 4(c), 4(d), and 4(e)
- *Radiation Protection Regulations*, paragraph 4(b) and subsection 13(1)

A.6.8 Emergency management and fire protection

The emergency management and fire protection SCA covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.

Note: This SCA includes conventional emergency and fire response. Fire protection operations, design and analysis are discussed in the appropriate SCA of operating performance, safety analysis or physical design.

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraph 3(1)(k)
- *Class I Nuclear Facilities Regulations*, paragraphs 3(f) and 3(k)

A.6.9 Waste management

The waste management SCA covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraphs 3(1)(j), 3(1)(k) and 3(1)(l)
- *Class I Nuclear Facilities Regulations*, paragraphs 3(e), 3(k), 4(a), 4(c)

A.6.10 Security

The security SCA covers the programs required to implement and support the security requirements stipulated in the regulations, the licence, orders, or expectations for the facility or activity.

Applicable regulatory basis:
- *General Nuclear Safety and Control Regulations*, paragraphs 3(1)(d), 3(1)(g), and 3(1)(h) and sections 21 through 23
- *Class I Nuclear Facilities Regulations*, paragraph 3(i)
- *Nuclear Security Regulations*, section 3

A.6.11 Safeguards and non-proliferation

The safeguards and non-proliferation SCA covers the programs and activities required for the successful implementation of the obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements as well as all other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons*.

Applicable regulatory basis:
- *Nuclear Non-Proliferation Import and Export Control Regulations*

This section also addresses the requirements of the following international protocols:
- IAEA INFCIRC/164, *Agreement between the Government of Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* [53]
- IAEA INFCIRC/164/Add.1, *Protocol Additional to INFCIRC/164* [54])

A.7 Other Matters of Regulatory Interest

The applicant shall address other matters of regulatory interest, as described in section 4, relative to site preparation and to the design of the proposed reactor facility.

Applicable regulatory basis:

- *General Nuclear Safety and Control Regulations*, paragraphs 3(1)(l) and (m) and subsection 3(1.1)
- *Class I Nuclear Facilities Regulations*, paragraph 3(j)

The specific other matters of regulatory interest that are relevant to an application for a licence to prepare site are:

- public information and disclosure program
- Aboriginal engagement
- intergovernmental consultation
- financial guarantees

For more information, see section 4.14, *Other matters of regulatory interest*.

Appendix B: Site Evaluation Program and Processes

B.1 General considerations

The process used for the evaluation of the site shall document:

- the methodology used to determine the suitability of the site over the full lifecycle of the proposed facility
- the processes used to manage the quality of work during site evaluation and the activities that verify compliance

Guidance

The site evaluation process should satisfy the criteria contained in the following documents that apply to the facility being considered:

- applicable federal environmental legislation
- either:
  - REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6]
    or
  - RD-367, *Design of Small Reactor Facilities* [33]
- EPS 1/PG/2 *Environmental codes of practice for steam electric power generation: siting phase* [59]
- CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]

B.2 Applicant's oversight of the site evaluation process

The applicant's site evaluation organization should be documented and include a description of relationships between the applicant and contractors used in the performance of site evaluation activities.

Guidance

A clear and direct oversight presence in every aspect of site evaluation should be demonstrated.

B.3 Process for gathering baseline data

Guidance

The applicant should document the process for reviewing the credibility and quality of data collection and the analysis methods used by consulting companies. Limitations and data gaps in the quality and completeness of baseline information should be identified and addressed. Specific attention should be paid to the adequacy of baseline data collection for those elements of the environment to be carried forward into future licensing phases with the objective of monitoring for a specified level of change in some environmental parameter or analyte. This process requires specific statistical study design considerations as outlined in CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11].

Where sampling is used to gather field data, standard sampling techniques and approaches should be from recognized government agencies and peer-reviewed published scientific literature for the appropriate technical discipline (for example, groundwater monitoring, fish monitoring).

Guidance contained in *The Inspector's Field Sampling Manual* [60] may be considered. This manual sets and implements national standards and uniformity for field sampling practices. It also serves as a training

manual and a reference guide for field inspectors. The manual describes planning, sampling in the field, sampling for specific media and protocols.

For more information on field sampling baseline, see:

- CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
- EPA *Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan* [61]

B.4 Process to evaluate natural and human-induced factors that may affect safety and security

The process used to define and evaluate evolving natural and human-induced factors over the lifecycle of the proposed facility that may affect safety and security shall be documented.

Guidance

The process should include factors such as:

- external events
- major planned facility evolutions such as plant life extension activities
- effects of the site on the environment
- changes to population density and land use in the emergency planning zone, including future facilities that may be difficult to evacuate

Appendix C: Baseline Data used to Evaluate Suitability Throughout the Lifecycle of the Nuclear Facility

C.1 General considerations

A comprehensive site evaluation includes a demonstration of the applicant's understanding of site-specific and regional baseline characteristics and their effect(s) on site operations. The site baseline data shall be sufficiently robust to support site evaluation claims.

Adequate and sufficient baseline data is required to confirm that:

- predicted effects of external events on the site are credible
- predicted effects of external events on site events, the predicted environmental effects and the testing of those predictions are credible
- the proposed plant design and the design of site infrastructure to be established are adequate

Guidance

For each site baseline data topic, the applicant should justify the size of the local and regional study areas used for that topic.

The applicant should describe uncertainties and types of uncertainties (for example, natural randomness, insufficient knowledge, and sampling or measurement error).

The applicant should demonstrate that the process used for each type of data collection is managed in a process consistent with the applicant's management system. The results of the site baseline characterization should be accurate, complete, reproducible, traceable and verifiable.

The applicant should identify and address limitations and data gaps in the quality and completeness of baseline information, including specifying the deviation from a reference condition that would be considered an adverse effect (taking into consideration the normal natural variation for that parameter). This analysis can be done through the implementation of statistical design into baseline studies.

The applicant should establish reference sites used to track changes that are not project-related, but that coincide with project activities (for example, bird nesting habits). This information is important to support site findings on baseline characterization of species occurrence. The applicant should specify the selection basis and planned use of reference sites.

Site baseline data submissions should, where appropriate, also provide details on the present human population distribution and land use and indicate how each of the topics described in appendix B has affected population distribution and land use (for example, seasonal floods may have rendered a particular area near the site unsuitable for industrial development).

C.2 Baseline climate, meteorological data and air quality data

Guidance

Information should include:

- prehistoric, historic, and instrumentally recorded climate data sources that reflect the regional conditions (for example, the "Canadian Climate Normals" webpage [18])

- five years of regional meteorological data to evaluate the potential environmental effects on the surrounding areas, or one year of site-specific meteorological data for the most recent one-year period:
  - this information should provide the atmospheric dispersion in the vicinity of the site and the surrounding areas
  - the assumptions used should be clearly identified under a separate header
  - conservatism should be addressed
- if available, information about climatic parameters as compared against references (if the information is not provided, an explanation should be included); for example:
  - air masses
  - general airflow
  - pressure patterns
  - frontal systems
  - temperature and humidity conditions
- information about the ambient air quality of the study areas prior to the initiation of the project
- a description of the methods used to identify nuclear and hazardous substances that will be included in the baseline air quality characterization
- topographic descriptions of the site area and information about local (site) meteorological parameters:
  - the information provided should establish that the data represents conditions at the site and its immediate vicinity
  - the location of onsite meteorological stations and other local sources of meteorological data should be described with respect to local topographic characteristics that could affect:
  - local airflow patterns (for example, local circulation conditions, such as “drainage flow”)
  - meteorological parameters (for example, temperature and humidity)
- if the site is located close to a lake, information about land-lake interactions
- extreme (minimum or maximum) and average values of meteorological variables for regional and onsite locations, including:
  - air temperature
  - relative humidity
  - precipitation
  - wind speed and direction
  - atmospheric pressure
  - solar radiation
- information about rare (infrequent) and other meteorological phenomena, owing to their possible effects on facility safety; for example, tornadoes, hurricanes (blizzards, dust and sand storms, drought, ice storms, hail and lightning

Five years of meteorological data should be used. Site-specific meteorological data may be used if it covers the most recent five-year period. The applicant should verify that the data covering the most recent one-year period is representative of the conditions at the site. If the data is not representative, then the five-year average data should be used.

The applicant should identify the locations of all meteorological and air quality data collection stations on an appropriately sized topographical map, and should include a justification of their locations.

The regional and local meteorological data should be appropriate as bases for:
- evaluation of potential changes in normal and extreme values
- severe weather phenomena
- air quality conditions resulting from:

- site preparation
- facility construction
- facility operation
- decommissioning
- site abandonment

Data on regional climatological and local meteorological conditions and phenomena should be adequate as bases for assessing the:

- effects on design and siting of the reactor facility and its heat dissipation system
- effects on the atmospheric environment resulting from site preparation, station construction, operation, decommissioning, and abandonment

Baseline information should demonstrate consideration of criteria contained in the following IAEA safety guides:

- NS-G-3.2, *Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants* [8]
- SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15]

For baseline air quality data, air quality assessment results should be compared against applicable provincial and federal air quality criteria and objectives, such as annual, 24-hour and one-hour maximum acceptable concentrations. Precise guidance can be obtained from provincial regulations and standards.

For complete hazardous substance analysis, volatile organic compounds (VOCs) are compared to ozone; to particulate matter related to total suspended particulates (TSP); to particulate matter < 10 µm (PM10); and to particulate matter < 2.5 µm (PM2.5). Sulphur dioxide (SO_2), nitrogen oxides (NOx) and carbon monoxide (CO) are included in the analysis.

For nuclear substance analysis, tritium oxide and tritium gas, carbon 14, noble gases, iodine-131, and particulates are to be included in the analysis.

C.3 Baseline geological, geotechnical, and coastal geomorphological data and baseline information on geotechnical and seismic hazards

The applicant shall document the following baseline data and information within the site, local and regional areas:

- geological history and physical, chemical, and mechanical characteristics of geological formations
- structural geology and tectonic setting
- geotechnical properties of overburden materials (within the site and local areas)
- coastal geomorphology (for example, erosion mechanisms and characteristics)
- natural or human-induced geotechnical hazards
- natural or human-induced seismic hazards

Guidance

The baseline information should address the criteria contained in the following documents:

- CSA N289.2, *Ground motion determination for seismic qualification of nuclear power plants* [19]
- CSA N289.3, *Design procedures for seismic qualification of nuclear power plants* [62]
- IAEA NS-G-3.6, *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants* [14]
- IAEA NS-R-3 (Rev 1), *Site Evaluation for Nuclear Installations* [1]

C.3.1 Geology and structural geology

The application shall define the data sources (literature review, borehole information, geophysical investigation, and so on). Data obtained from in-situ investigations will include borehole locations; their positions relative to the planned facility should be shown on maps. If no in-situ data exists in the footprint of the proposed facility, the applicant shall justify other applicable data.

The application shall present geological history of the area, including information on bedrock lithology and stratigraphy. Relative and absolute age information shall be included where available, based on published government reports or journal articles.

The application shall document three-dimensional models of the geology and structural geology at three different scales (site, local and regional scales). Cross sections through the three-dimensional models showing the geological units, unit thicknesses, and structural information shall be provided.

In addition to classical geological information, the application shall describe the physical, chemical, hydrogeological and mechanical properties of rocks and overburden materials.

For structures such as faults, lineaments and arches, the application shall assess their seismogenic potential and their potential to constitute preferential groundwater flow paths, with a description of their tectonic setting.

C.3.2 Geotechnical data

The application shall provide cross-sections showing the soil deposits (with a definition of the soil units) and the upper bedrock and the groundwater levels. For data obtained with in-situ investigations, the location of the boreholes shall be indicated on maps and cross-sections with their positions relative to the planned facility shown. If no *in-situ* data exists in the footprint of the proposed facility and immediate vicinity, the applicant shall justify other applicable data.

The application shall provide the geotechnical properties of the soil units, such as index properties, shear strength, deformation characteristics, and liquefaction potential. The application shall provide dynamic properties (such as shear wave velocities, damping ratio, shear modulus) to be used in soil response and soil-structure interaction analyses.

C.3.3 Coastal geomorphological data

Guidance

The application should identify possible mechanisms for coastal erosion in the vicinity of the proposed facility, and should include both natural (such as high lake levels) and human-induced (engineering structures along the shore, dams on contributing rivers, and so on).

The application should provide estimates of the rate(s) of erosion of shores or riverbanks on or near the site. These estimates should be conducted for the average long term and also for the historical occurrence of unusual events (for example, unusually high lake or sea levels.)

The application should include assessments of how:

- coastal erosion could affect site facilities
- the activities to be licensed for each licensing stage of the site would affect coastal erosion

C.3.4 Characterization of potential geotechnical hazards

Assessment of geotechnical hazards shall include consideration of factors such as slope instability, underwater instability, collapse, subsidence or uplift of site surfaces and instability of soil foundations due to static or dynamic loads.

Guidance

Evaluations of these hazards should include information about:

- natural or human made slopes in the vicinity or on the site whose failure could affect the safety of the site facilities
- underground excavations in the vicinity or on the site whose failure could affect the safety of the workers and the site facility
- the geographical location of any sub-surface features on or near the proposed site such as:
  - caverns
  - karstic formations (that is, soluble bedrock – such as limestone, dolostone and evaporates – that has been eroded to produce formations such as ridges, towers, fissures, sinkholes and caves)
  - human made features such as mines/quarries, water wells and oil wells, and water reservoirs
- soil units that could liquefy under seismic conditions (liquefiable materials are usually loose sands below the phreatic surface)
- collapsible soils, expansive soils, and swelling types of rock that could create significant problems for the facility's foundations (*Canadian Foundation Engineering Manual* [63])
- geological processes (for example, glacial rebound, tectonic force) that are responsible for subsidence or rebound and estimated rates of subsidence and rebound attributed to these processes

C.3.5 Characterization of potential seismic hazards

The applicant shall conduct a site-specific seismic hazard assessment, including a paleoseismic investigation and probabilistic seismic hazard analysis, to develop ground motion response spectra. Sufficient information shall be provided to characterize the seismology for both the facility design basis and design extension conditions (beyond design basis).

Guidance

The seismic hazard assessment for the site and region immediately surrounding the site should include:

- seismic sources identified through a review of the seismic records
- identification of faults in the regional, local and site scales; note that the potential that these faults are seismogenic should be evaluated
- the determination of magnitude-recurrence relationships for the seismic sources
- the prediction of seismic motion in terms of response spectrum, peak ground acceleration, or any other pertinent measure of the earthquake's intensity at the facility's site (this information will be used in the earthquake-resistant design of the foundations, and the structures, systems and components of the facility)

Active faults may not be found even in well-mapped places. These undetected faults may or may not change the estimated hazard, depending on the relative contribution of the faults compared to the other sources that have been included.

The assessment should be developed using the most current knowledge, information, and standards, such as:

- CSA N289.1, *General requirements for seismic design and qualification of CANDU nuclear power plants* [64]
- CSA N289.2, *Ground motion determination for seismic qualification of nuclear power plants* [19]
- CSA N289.3, *Design procedures for seismic qualification of nuclear power plants* [62]

C.4 Baseline hydrology – normal flow, flood and drought

The applicant shall identify surface-water bodies that could affect the facility's water supply and effluent or that could be affected by facility construction, operation, decommissioning or abandonment of the proposed project (including transmission corridors). In addition, the applicant shall provide site-specific and regional data on the hydrological characteristics of the above surface water bodies under normal, flood and drought conditions.

C.4.1 General surface-water

Guidance

The following information should be provided, where applicable:

- maps (including digital databases such as a geographic information system (GIS)) showing the relationship of the site to major hydrological systems that could affect or be affected by plant construction, operation, decommissioning, or abandonment
- for surface-water bodies used as a heat sink or process water source, information about maximum, average maximum, average, average minimum, and minimum monthly temperature of the water bodies
- for surface-water bodies and wetlands, estimated erosion characteristics and sediment transport, including rate, bed, and suspended load fractions, and graduation analyses; a description of the floodplain and its relationship to the site
- a description of wetlands and their relationship to the site
- the design-basis flood (DBF) elevation and the DBF discharge, if applicable; the derivation of the DBF should be described

C.4.2 Freshwater streams

Guidance

Characterization information should include a list of major streams, size of drainage areas, stream order and gradient. For each of the major streams listed, the following information should be documented:

- maximum, average maximum, average, average minimum, and minimum monthly flow
- flood frequency distributions, including levee failures
- flood control measures (reservoirs, levees, flood forecasting)
- historical drought stages and discharges by month, and the seven-day once-in-10-years low flow
- important short-duration flow fluctuations (for example, diurnal release variations from peaking operation of upstream hydroelectric project)
- within the influence of the intake and discharge structures, velocity distribution (horizontal and vertical), bathymetry at and near the intake structure, bathymetry at and downstream of the discharge structure, and stream cross-sections
- other hydrographic modifications (for example, diversion dams, channelization)
- a list of wetlands and floodplains and their seasonal characteristics

C.4.3 Lakes and impoundments

Guidance

Characterization information should include a description of lakes or impoundments that could be affected by the project.

For each of the lakes or major waterbodies described, the following information should be documented:

- where influenced by the intake or discharge structures, size, location, and elevation of outlets
- where influenced by the intake or discharge structures, elevation-area-capacity curves
- a summary description of lake operating rules (for example, motorboat capacity)
- annual yield and dependability
- variations in inflows, outflows, water surface elevations, and storage volumes and retention time
- waves (statistics of wave heights, run-up, and so on), including:
  - information about historic seiche activity
  - where waves can affect the safe operation of the facility, information about the design basis wave conditions (including how those conditions were derived)
- net loss, including evaporation and seepage
- information about current patterns:
  - including frequency distributions of current speed, direction, and persistence
  - at the local and regional spatial scale
  - at the whole-water body spatial scale within a reasonable distance from the site
- temperature distribution (horizontal and vertical) and stratification and seasonal variations of density induced currents
- detailed bathymetry in vicinity of planned station intake(s) and outfall(s)
- where lake level can affect the safe operation of the facility, the design basis maximum and minimum lake levels, including how those levels were derived

C.5 Baseline surface water, sediment and groundwater quality data

The applicant shall evaluate the baseline surface water quality, sediment quality and groundwater quality relative to established standards, criteria, guidelines and/or objectives, to ensure that changes due to a given project do not pose a present, imminent, or long-term risk to human health and the environment.

C.5.1 Contaminants of potential concern

Guidance

Concentrations of contaminants of potential concern (COPCs) in groundwater, surface water and sediments should be measured at detection limits that allow comparison to criteria and objectives ("benchmarks") that protect human and/or aquatic life. The benchmark selection for each COPC should be supported by scientific literature that justifies its use for the proposed site.

C.5.2 Baseline surface water quality

The applicant shall report baseline surface water quality, including general water quality parameters (for example, pH, conductivity, temperature, and dissolved oxygen). The expected COPCs shall form the basis of the parameters to be analyzed in baseline surface water samples.

The application shall include sample station locations, along with the justification for their selection and statistical basis (number of samples and variability) by which "baseline" is defined.

Guidance

The focus should be on those parameters expected to change as a result of project activities assessed throughout all licensing stages.

Baseline surface water quality data should be initially screened against recognized water quality guidelines, such as the *Canadian Environmental Quality Guidelines* [65] . Where federal or provincial standards or guidelines are not available or where natural background as documented in an appropriate baseline study demonstrates the water quality standards or guidelines are not applicable, benchmarks from the peer-reviewed scientific literature may be used with appropriate rationale. Site-specific water quality objectives may be developed with the support of the scientific literature and the application of the procedures for deriving numerical water quality objectives as documented in the *Canadian Environmental Quality Guidelines*.

For more information, refer to the *Canadian Environmental Quality Guidelines* [65], specifically the *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

C.5.3 Baseline sediment quality

The applicant shall report on baseline sediment quality, including sediment physical parameters (for example, pH, total organic carbon, and particle size analysis). The expected COPCs shall form the basis of the parameters to be analyzed in baseline sediment samples. The application shall include sample station locations, justification for their selection and statistical basis (number of samples and variability) by which "baseline" is defined.

Guidance

The focus should be on those parameters expected to change as a result of project activities assessed throughout all licensing stages.

Baseline sediment quality data should initially be screened against federal sediment quality guidelines, such as the *Canadian Environmental Quality Guidelines* [65]. Where an appropriate baseline study demonstrates that natural background exceeds the available standards or guidelines (or that none exist for the COPC of interest), sediment quality benchmarks from the peer-reviewed scientific literature should be used with appropriate rationale.

C.5.4 Baseline hydrogeology and groundwater quality

The applicant shall determine and report baseline groundwater quality, including pH, conductivity and turbidity. The expected COPCs shall form the basis of the parameters to be analyzed in baseline groundwater quality samples. The report shall include sample station locations, justification for their selection and statistical basis (number of samples and variability) by which "baseline" is defined.

Guidance

The focus should be on those parameters expected to change as a result of project activities assessed throughout all licensing stages.

Baseline groundwater quality data should be compared to federal water quality guidelines, such as the *Canadian Environmental Quality Guidelines* [65]. If federal or provincial standards and guidelines are not available, water quality benchmarks from the peer-reviewed scientific literature should be used with appropriate rationale.

Groundwater elevations and hydraulic heads

The acquisition and interpretation of groundwater level and hydraulic head measurements are important elements of hydrogeological characterization. Aquifer physical properties and hydraulic head measurements allow the rates and directions of groundwater flow to be estimated.

Groundwater elevations and hydraulic heads should be presented as contour maps. Seasonal variations should also be presented.

Lithological logs, well construction drawings and borehole geophysical logs

Lithological logs, well construction drawings and borehole geophysical logs are used to develop and support hydrogeological characterization, groundwater monitoring programs, and groundwater remediation.

Hydrogeological cross-sections

The applicant shall document site-specific hydrogeological cross-sections.

Guidance

Hydrogeological cross-sections illustrate the distribution of geological materials and hydraulic properties that control groundwater flow and influence contaminant transport. Identification of vertical and horizontal groundwater flow paths supports hydrogeological characterization, groundwater monitoring programs and groundwater remediation. The resulting hydrogeological cross-sections provide a basis for interpreting and illustrating contaminant distributions.

Cross-sections should incorporate available geological and hydrogeological information, including lithological logs, cone penetrometer logs, borehole geophysical logs, surface geological mapping, surface geophysical surveys and trench logs. Cross-sections should be drawn to scales that depict important site features. Cross-sections and accompanying maps should be maintained using the same scales.

Cross-sections should depict the interpretation of hydrostratigraphy (that is, the mapping of surface and sub-surface water flow pathways for characterization and remediation activities). The rationale for the interpretation should also be documented. Cross-sections should be amended as additional monitoring or geological data are developed. If new data result in significant changes to the conceptual models, the results should be reported. Final drawings should accompany both draft and ongoing remedial investigation reports.

Structure contour maps

The applicant should provide site-specific geological structure contour maps illustrating the interpreted elevation of geological contacts, thickness of geological units and the saturated thickness, extent, and overall geometry of hydrostratigraphic zones. If new data result in significant changes to the conceptual models, the changes should be reported. Final drawings do not need to be submitted until the draft remedial investigation report is due.

Site-specific structure contour maps should use the same scale(s) as groundwater. Contour intervals should be selected commensurate with the density and precision of the data.

Maps should be amended (and include the amendment date) as additional monitoring or geological data are developed.

Groundwater elevation contour maps and potentiometric surface maps

Groundwater elevation contour maps provide for illustration and interpretation of the horizontal distribution of hydraulic head across a study area. These maps, combined with knowledge of aquifer hydraulic properties, estimate rates and directions of groundwater flow (and associated contaminant transport) within specific hydrostratigraphic zones.

The applicant should provide groundwater elevation contour maps for each water-bearing zone, to illustrate the extent of water-bearing zones, horizontal groundwater flow directions, and to support interpretation and illustration of the groundwater flow system.

Site-specific groundwater elevation maps should be drawn to scales that depict important site features.

Groundwater elevation contour maps illustrate the horizontal distribution of hydraulic head. The vertical distribution of hydraulic head should be illustrated on cross-sections. All potentiometric data used to develop individual contour maps should be from the same hydrostratigraphic zone and possibly from the same relative position. Groundwater elevation contour maps should incorporate all potentiometric data from a single groundwater elevation survey for the hydrostratigraphic zone illustrated. Groundwater elevation data should be posted with the well identification on each map.

Aquifer properties

The applicant shall document estimates of the hydraulic properties of hydrostratigraphic units. These estimates shall include hydraulic conductivity and porosity of aquifers and aquitards, and the transmissivity and storage coefficient of aquifers. This information aids in subsequent determinations of monitoring locations and frequencies, predictions of contaminant fate and transport, and design of remedial measures.

The applicant shall identify the method used to estimate hydraulic properties, whether from pumping tests, slug tests, or laboratory tests of core samples.

Guidance

The applicant should document anisotropy of hydraulic properties. The range and spatial distribution of hydraulic conductivity and/or transmissivity should be depicted in graphical form, on maps and cross-sections.

Rates and directions of groundwater flow

The applicant shall use hydraulic properties, in conjunction with water level and gradient information, to estimate rates and directions of groundwater flow, the rate of transfer of water between aquifers, and the capture zones of wells.

Guidance

The application should include any chemical or isotopic tracer data that provide constraints on fluid direction, flow velocity or mixing.

The rates and directions of groundwater flow in each hydrostratigraphic unit should be described using potentiometric data and hydraulic properties, t and depicted on maps and cross sections.

Potable groundwater supplies

Characterization information shall describe any potable groundwater supplies, their current and potential use near and around the proposed plant.

Guidance

Characterization should include maps showing the locations of the groundwater supplies.

Baseline water quality

Baseline water quality, including general water quality parameters, shall be documented.

Guidance

The sample locations and statistics used to define baseline water quality should be justified.

Well purge and recovery rates, well volume, purge volume, temperature, specific conductance and any other parameters measured in the field should be reported for each well sampled.

Graphs illustrating historical analytical data for COPCs should be provided for selected wells. Trends in concentrations should be interpreted and described.

C.6 Baseline terrestrial flora, fauna and food chain data

Aquatic mammals, waterfowl, amphibians and aquatic-associated reptiles (for example, turtles) are included in this category. Information about the terrestrial biotic environment to be obtained for the site and surrounding areas shall include:

- maps that identify important terrestrial habitats on and in the vicinity of the site
- descriptions and maps of the area occupied by each natural and human-made habitat type
- descriptions and maps of major soil types in the site, local and regional study areas
- a list and description of important floral and faunal species and their spatial and temporal distribution on and in the site's vicinity (including abundance, critical habitat, and life histories that include critical life stages, biologically significant activities, seasonal habitat requirements, trophic, and interspecific relationships)
- characterization of the existing vegetation communities (ecological land classification) to assess the likely effects on potential valued component (VC) habitat suitability/availability and potential direct effects on plants identified as potential VCs
- description of existing wildlife communities to evaluate likely acute and chronic toxicity or direct mortality effects on fauna (birds, mammals, amphibians, reptiles, and invertebrates)
- identification of any conservation status species (that is, species designated at risk by a government agency, that are known to occur, or have the potential to occur within the zone of influence of project activities), and including an assessment of the importance of the habitat within that zone for these species
- locations of travel corridors for important terrestrial species and alternate routes for those corridors that could potentially be affected by the site's use
- description of wetlands and their relationship to the site
- description of natural and human-induced pre-existing environmental stresses and the current ecological conditions that indicate such stresses
- description and location of any recent or currently in progress ecological or biological studies of the site or its environs

- description and map of boundaries of the proposed project in a regional context, showing existing and planned future land use, and existing infrastructure

The biotic characteristics of the proposed site shall be identified and documented, while taking into account environmental considerations such as: habitats essential to maintaining the viability of potential VCs, designated protected habitats, areas containing migratory routes of important species, and areas of high biological production.

Characterization shall also contain a description of soil types at the site and within local and regional study areas and the quantitative baseline data of the soil characteristics that are most likely to influence future assessments and required for modelling purposes (e.g., pH, soil bulk density, soil moisture content).

Guidance

Documentation of biota using habitat at the proposed site should include descriptions of communities of birds, mammals, and reptiles. This information helps to identify interactions between the project and the biological components of the area, to predict potential environmental effects, to identify mitigation measures, and to evaluate the significance of the residual effects when the mitigation measures are applied. Biological data play an important role in the identification of potential VCs, which are used as the final receptors in pathways modelling.

Background information should be documented for understanding the potential changes in, or effects on, the terrestrial environment and the adequacy of environmental monitoring programs to identify these potential changes. Consideration should be given to the need for and design of wildlife population monitoring (for example, spatial distribution, abundance, and density) to put residual adverse effects into proper context for those species at risk. Population monitoring is complex and requires estimates with minimum bias and maximum precision.

The area of consideration may extend beyond the regional study area to include potential VC home ranges, critical habitats, and migration corridors. The boundaries in space and time take into account the home range, migration corridors and dispersal areas of potentially affected species. The VC information is used to adjust the assessment spatial and temporal boundaries.

For commercially or recreationally valuable species, the applicant should list the types of wildlife and plants that could be adversely affected by the proposed facility. The provincial, local conservation agencies or organizations that maintain harvest level records of these species should be identified.

C.7 Baseline aquatic flora, fauna and food chain data

C.7.1 Baseline aquatic biota and habitat

Characterization information shall address the site and surrounding region potentially affected by the project, such as the following:

- aquatic finfish, shellfish and their prey (for example, benthic and other aquatic invertebrates, phytoplankton, zooplankton) and aquatic plants
- identification of any conservation status species designated as species at risk by a government agency that are known to occur or have the potential to occur within the zone of influence of project activities, including an assessment of the importance of the habitat within that zone for these species

- aquatic habitats of aquatic finfish, shellfish and their prey that are pelagic (open water), littoral (near-shore and shallow), benthic (bottom-associated), riparian (shoreline) and wetland, onsite ponds and streams that provide habitat for aquatic biota, and include:
  - parameters of habitat quality, quantity and frequency of use
  - all lentic (standing water) and lotic (flowing water) water bodies, wetlands located within the geographic study areas
  - fish habitat mapping, including spatial and temporal variation by life stage for spawning, nursery, rearing, feeding, refuge/cover, wintering and corridors for movement, considering that:
    - the spatial scale of mapping beyond this level is governed by interaction with the project
    - this mapping includes streams that contain fish for substrate type, cover and structure (run, riffle, pool) and stream channel morphology, according to published protocols from government agencies or externally peer-reviewed references
    - the area of consideration may extend beyond the regional study area to include potential VC home ranges, critical habitats, natural corridors (for example, larval and adult fish migration corridors)
    - the boundaries in space and time take into account the home range, migration corridors and dispersal areas of potentially affected species
    - the VC information will be used to adjust the assessment boundaries; aquatic mammals, water birds, waterfowl, reptiles and wetlands as potential VC entities considered in section 3.4, Gathering Baseline Data
- general criteria used to identify aquatic and wetland VCs that may be affected by the project, and consider that:
  - typically the list of VCs that result from stakeholder consultation is too long to be of practical use and selection criteria must be applied to reduce the list to a manageable size
  - the VC selection criteria must be clearly stated and the manner in which they were applied to come up with the final list of VCs
  - a supporting rationale statement is expected for each VC and must clearly describe how the preliminary list was changed in response to external input
- mapping of watersheds, sub-watersheds local, site, regional areas and size of drainage areas showing types of land use (for example, pasture cattle, cottage, housing, aggregate extraction former or active) tied into ecological land classification mapping done for terrestrial baseline work
- existing physically altered or contaminated habitats (for example, seasonal or annual concentrations above background) that were changed by past operations at sites where there is an existing facility (for example, thermal discharge channels, thermal plumes and past/present physical disruption/structures in near-shore uplands, shoreline/riparian and water bodies)
- for existing facilities on the same site, a description of the zone of influence of existing thermal plumes in horizontal and vertical space with maps and plots (for example, delta above ambient versus distance alongshore and offshore relative to maps of lake bottom depths and substrates); note that the zone of influence should be based on site-specific information
- fish habitat mapping that includes existing operations thermal discharge areas of elevated temperatures and physical disruption of lake currents (depth and area) identification of habitats exposed to existing facility stressors and those potentially exposed through data review and field reconnaissance, including:
  - contaminant and thermal effluents and plumes
  - storm water release points
  - present and projected radiological and conventional groundwater contaminant plumes
  - hydrological characteristics associated with any identified critical fish habitat (see appendix C.4)
  - nuclear and conventional accidents and spills
- the distribution, density and type of aquatic plants in shoreline and wetland areas

- baseline habitat information for VCs, including data from reference sites as close as possible to the project site, but unlikely to be on an exposure pathway from the project; note that:
  - actual reference site sample data is preferred
  - if actual reference site sample data or filling gaps in sparse reference databases is not possible , calibrated and validated model estimates of baseline habitat condition are acceptable when linked to proposed VC responses,
- baseline characterization field study of site reference areas that provide habitat for aquatic biota, providing typical values and variability for types of aquatic biota present and chemistry of water and sediment
- the potential effects of climate change on habitat suitability and how that may alter spatial distributions of biota (for example, temperature and water level change effects on location and timing of use of spawning habitat by lake and round whitefish)
- habitat criticality and frequency of use in space and time for VC, to determine overlap with stressor exposure distributions in space and time
- review of past site clearing and shoreline development, if applicable (this information determines the succession trajectory of the site habitat)
- background ranges for measured habitat characteristics, especially those that may be affected by the project (for example, temperature, flow, turbidity, water and sediment chemistry, percent cover streams)
- background information on the potential changes and effects on the aquatic environment and the adequacy of environmental monitoring programs including:
  - site background information (for example, history of past exposure) and biological life history information that affect population growth rates
  - the capability to recover from adverse effects (factors to consider include development and maturation time, longevity, generation time, body size, maximum population growth rate per generation, fecundity, likelihood of migration)
- cover and standing biomass for aquatic plants as a basis to predict and detect changes
- adequate characterization of the VC structural attributes (for example, population range and size, density, age/size distributions, and so on) and functional attributes (for example, food type, ingestion rates, activity, bioaccumulation, and so on)
  - including the specific attribute that is the focus in this assessment as important to protect and may be affected by the project
  - for example, for a specific fish species, this characterization would include whether the population geographic distribution of the species is likely local, regional or lakewide; whether it is a stream, wetland or lake spawner; and so on
  - this characterization should also include a statement on the level of confidence attached to the information for each species
- information on the stability of VCs (variability in key biological attributes) and present levels of exposure to stressors
  - these aspects affect VC vulnerability or the capability to cope with additional project interactions
  - documentation of baseline values and ongoing trends (normal seasonal and year-to-year fluctuations) for standard biological attributes for the VCs (for example, density, biomass, richness, abundance, community indices, growth, size and age distributions)
- information on the variation in spatial distribution (for example, depth) and seasonal distribution by life stage for each VC
- an aquatic species inventory list based on field studies for the site and local study area and available published information for the regional study area, including:
  - the list of fish, benthic invertebrates and major macrophyte species, based on species collected in field studies on the site and local area and those species expected to be found in the area based on

regional studies with some indication on their relative abundance and the presence of protected species
- evidence that the information is representative, including identifying species from literature or atlases that are expected but were absent during past surveys

Guidance

Characterization information should also consider:
- statistical design for baseline monitoring or the rationale for aspects that may not be amenable to statistical design
  - special consideration should be given to the requirement and design of finfish or shellfish population monitoring (for example, spatial distribution, abundance, and density) to put residual adverse effects into the proper context for species that should be at risk
  - note that the complexity of population monitoring requires the sample survey statistical design to produce unbiased, precise estimates
- that the inferential basis for information provided on the use of habitat types and species is transparent including comments on the quality of the inference (for example, field observed or estimated from models or published species range atlases or maps)
- Fisheries and Oceans Canada (DFO) fish habitat requirements
- provincial and conservation authority agency standards for classification, mapping and evaluation of fish habitat
- habitat suitability model criteria from:
  - *Habitat Suitability Index Models: Lake trout (exclusive of the Great Lakes)* [66]
  - *Assessing the ecological effects of habitat change: moving beyond productive capacity* [67]
- riparian habitat guidelines for assessment of present condition streams onsite or within the exposure zone
- federal and provincial water and sediment quality objectives/guidelines, including total suspended solids and turbidity
- mapping of lake shorelines and wetland substrate types, according to a federal or provincial government agency or published reference

C.7.2 Baseline food chain data

Characterization information shall include:
- conceptual models of existing baseline aquatic biota endpoints (for example, survival, growth, reproduction, age/size distributions) including linkages with abiotic environmental media and other biota (feeding); the conceptual model shall:
  - describe the baseline sources and distribution of stressors along transport and exposure pathways resulting in baseline hazard quotients for contaminants to aquatic organisms through diet and direct exposure
  - include potential VCs from each trophic level (for example, piscivore, benthic prey feeder, zooplankton feeder, herbivore, primary producers)
- descriptions of any background changes expected in energy transfer from field results and agency literature of present trends in near-shore and offshore food web; for example, existing disruptions of food webs and associated community dynamics as a result of non-project related influences (such as the effects of invasive species on Great Lakes food webs and associated aquatic communities) which must be considered when considering project related interactions and effects into the future
- baseline fish and fish prey (benthic invertebrate) tissue concentration levels (typical values and variability) for radionuclides and chemicals for existing exposure areas and reference sites

- baseline information on the benthic invertebrate community for representative habitats (for example, exposed rocky inshore areas; embayment wetland) to allow the calculation of standard endpoints quality and quantity of information on benthic invertebrate community consistent with:
  - Environment and Climate Change Canada technical guidance on environmental effects monitoring [68] and scientific literature protocols
  - data from collections in the site and local study area
- reference locations that would not be exposed to project effects made over multiple years to understand natural year-to-year variability

C.8 Baseline ambient radioactivity and ambient non-radioactive hazardous substances

For hazardous substances or hazardous waste [9], characterization information shall address:
- characteristics of the ambient radioactivity and non-radioactive hazardous substances for the proposed site and the surrounding area
- projected baseline for ambient radioactivity and ambient hazardous substances during site preparation activities and for the long term during all succeeding licensing phases

Characterization information shall include:
- baseline concentration of nuclear and hazardous substances in the environment; regional background and/or historical data should be provided where possible
- detailed maps to show the locations of sampling/monitoring stations for measurements of nuclear and hazardous environmental concentrations
- an inventory of natural and anthropogenic sources for nuclear and hazardous substances at the site and within local and regional study areas
- criteria/benchmarks used in the evaluation of effects associated with nuclear and hazardous substances in the aquatic and terrestrial environment
- relevant pathways of exposure to nuclear and hazardous substances for aquatic and terrestrial biota
- background radiation doses to aquatic and terrestrial receptors from all natural and anthropogenic sources
- predicted/estimated concentrations of nuclear and hazardous substances as a result of the project, including comparisons to baseline conditions
- selection of potential aquatic and terrestrial VCs for the project based on concentrations of nuclear and hazardous substances in the aquatic and terrestrial environment
- predicted/estimated radiation doses to aquatic and terrestrial VC receptors from the project including comparisons to baseline conditions
- parameter values used to predict/calculate the environmental concentrations of nuclear and hazardous substances or exposure to aquatic and terrestrial VC receptors
- assessment of effects from potential changes in the aquatic and terrestrial environment from predicted nuclear and hazardous substance concentrations and predicted cumulative effects
- identification of mitigation measures for project phases to minimize or eliminate the effects of the project on potential aquatic and terrestrial VC receptors

Guidance

A greenfield site has natural ambient radioactivity present.

Ambient radioactivity baseline information should consider:
- CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
- IAEA RS-G-1.8, *Environmental and Source Monitoring for Purposes of Radiation Protection* [69]

Ambient hazardous substances baseline information should consider:

- CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
- federal guidelines; for example, the *Canadian Environmental Quality Guidelines* [65], specifically the *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*
- provincial guidelines and standards; for example, *Operations Manual for Air Quality Monitoring in Ontario* [70]
- international and foreign guidelines and standards; for example, EPA QA/G-5S, *Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan* [59]

The typical, natural variation in nuclear and hazardous substances concentrations at reference sites should be described and documented by implementing a statistical design into the baseline studies. Uncertainties and types of uncertainties included in the data (for example, natural randomness, insufficient knowledge, and sampling or measurement error) should be specified.

C.9 Baseline land use data

Baseline land-use information is used to predict the effects on the proposed site operations, and of the site operations on the environment. In addition, future changes in land use shall be taken into account in the assessment.

Land-use information is a major factor in determining the suitability of the site from a health, safety and environmental perspective, and the appropriate size of the site's proposed exclusion zone.

A detailed description of the baseline uses of land in the local and regional study areas shall be documented. Data is not expected to include an economic study of land values or cultural and heritage issues.

Guidance

Characterization information should:

- provide a brief history of land use in the regional study area, including any information on major industries in the vicinity of the proposed site
- identify local agencies, user groups and Indigenous peoples interested in local land uses and resources for previous projects in the regional study area; note that land use information from Indigenous peoples may require separate studies to quantify using land for hunting, fishing, trapping, medicinal plant gathering, habitation, spiritual, ceremonial, burial, or any other traditional pursuits
- consider and identify information collected and analyzed by federal, provincial or municipal agencies responsible for land-use management
- consider and identify information contained in provincial land use policies and regional/municipal official plans, relevant to the regional study area for current and planned land uses
- provide a description of primary recreational land uses
- describe existing and proposed modes and routes of transportation that will be used throughout the site preparation activities and subsequent phases of the project
- provide natural resources data; for example:
    - commercial fishing, including catch and quota, for the previous 10-year period
    - timber harvesting
    - oil, gas and mineral extraction data

Considerations of future land use should include expected or credible changes to the current land use (for example, possible future municipal development on adjacent property, based on the uses permitted in the official plan).

For studies based on interviews with resource users, the methods used to conduct the study should be described, including interview questions that demonstrate how the process validates the studies' results (for example, on traditional use of lands).

Appendix D: Security baseline data – security risks presented by the site's location

Characterization information related to this topic shall be considered to be prescribed information under the *Nuclear Safety and Control Act* (NSCA) and be adequately protected.

A site selection threat and risk assessment (SSTRA) is conducted prior to the submission of an application for a licence to prepare site. The resulting report contains an analysis of physical barriers to security presented by the location of the site over the proposed lifecycle of the project. The intent of the SSTRA is to aid the applicant in determining the suitability of the site from a security perspective. The information from the SSTRA feeds into the development of appropriate security mitigation measures for activities to be encompassed by a licence under the NSCA.

The SSTRA report and its basis information shall be maintained as security baseline characterization data for the lifecycle of the facility. The following subsections provide additional guidance for the development and management of SSTRA information.

Guidance

For guidance on the proposed format of the SSTRA report, the applicant's security organization should contact the CNSC's Directorate of Security and Safeguards at cnsc.info.ccsn@cnsc-ccsn.gc.ca.

D.1 Site selection threat and risk assessment management

The SSTRA report shall describe the applicant's organization that provided oversight for the SSTRA process.

Guidance

The description should demonstrate the organization's technical capability to perform the assessment and assess mitigation measures, and include:

- the composition of the team, member names, titles, position in the organization, area of expertise or input to the report, relevant qualifications and experience
- contributing organizations or subject matter experts not identified as team members or intelligence sources

D.2 Quality assurance of the site selection threat and risk assessment

The SSTRA report shall describe how the SSTRA was developed under a quality assurance or management system that is designed to continually improve performance based on established principles.

Guidance

The SSTRA report should describe the following elements necessary for verifying the quality of the SSTRA:

- methods of verifying accuracy and completeness of data
- descriptions of assumptions and interpretations of legal guidance
- methods of documenting storing and retaining SSTRA basis records for future security analyses
- details of the program or process to periodically review and update the SSTRA with a goal of merging processes into the future site threat and risk assessment analysis process

D.3 Policies and procedures

The SSTRA report shall identify security policies, procedures, standards, guides or related documentation that provide the basis for the management and conduct of the SSTRA.

Guidance

The SSTRA report should identify procedures and processes that may require development based on SSTRA findings.

D.4 Description of the site selection threat and risk assessment methodology

D.4.1 Analysis methods

Methods of performing the SSTRA shall be described, including:
- process flowcharts, with SSTRA critical phases identified and described
- descriptions of the theoretical frameworks or types of risk analysis methodologies used (for example, fault trees, CARVER or other attack modelling software)
- descriptions of assessment considerations or limitations

D.4.2 Intelligence sources

Intelligence sources used to gather threat related data in support of the SSTRA should be identified, including:
- government sources
- threat trending and analysis
- local sources
- law enforcement sources
- non-governmental sources of intelligence-related data

D.5 Results of the analysis

D.5.1 Information about the site

Guidance

The site location should be described using illustrations (including topographical maps) of all threat environments, risks or vulnerabilities presented by the location of the site.

Information about the site should include:
- for the application for a licence to prepare site:
  - a layout of all configurations of site structures being considered
  - proximity to provincial or national borders
  - location of the nearest communities

- for all licensing phases:
  - a description of safeguard requirements
  - landscape features overlooking the site (topographical details)
  - proximity to access roads (including road size, traffic patterns and bounding vehicle types)
  - proximity to rail corridors (including traffic patterns and cargo characteristics)

- proximity to water and navigable water routes (including traffic patterns, and cargo characteristics and bounding ship types)
- proximity to airports and air access routes (including traffic patterns and bounding aircraft types)
- proximity to publicly accessible areas or buildings around the site
- specific details of industrial operations surrounding the site and threats they may present to the site

D.5.2 Identification of threats and resulting risks that could affect the site

Descriptions of threats and resulting risks shall be documented with the full-project lifecycle in mind for areas on or near the site including vulnerabilities due to forecasted changes in land use:

- vulnerabilities from landscape features
- vulnerabilities from water approaches
- vulnerabilities from land approaches
- areas where visibility or detection methods may be affected by weather-related events such as snow and fog
- areas where blind approaches require additional security mitigation
- areas where blockades might make the site vulnerable
- areas where normal public access might distract security staff with nuisance alarms/alerts that provide unnecessary diversion of security personnel from other areas

For deliberate threat events to the site, a description of the various threat agents shall be documented, including an assessment of organizational capabilities, motivations, and equipment. The likelihood of the threat events being realized by threat agent action shall be analyzed.

The SSTRA report shall contain all relevant intelligence data related to threat agents and events to support conclusions. For non-deliberate threat events, a brief description of the event shall be documented, including a description of the potential vulnerability concerns and estimates of event occurrence based upon historical and statistical data.

Guidance

Consideration should be given to the target suitability, feasibility of the action, and acceptability to the threat agent.

Postulated events should be identified for each threat, including events that could cause loss of or harm in the site preparation or construction phase. These events should be categorized as deliberate or non-deliberate. The bounding postulated events and accompanying rationale should be identified.

D.5.3 Mitigation of identified threats and risks

The SSTRA report shall identify:

- risk acceptance criteria developed and employed to manage the threat
- at a high level, possible mitigation measures and countermeasures for each threat, as appropriate for the likelihood of the threat events

An explanation of the amount of risk reduction expected when proposed countermeasures or security measures are implemented to reduce the risk to an acceptable level shall be documented.

Guidance

For each proposed mitigation measure, the explanation should include residual security risks remaining after mitigation, so as to ensure that residual risks will not present unreasonable challenges to the future site security program (for example, mitigation may result in new security enhancements that were not anticipated).

D.6 References used in the site selection threat and risk assessment

Guidance

All references used as the basis for the SSTRA should be listed and include:

- policies, procedures and guidelines
- industry references
- contributory reports

Classified source information should be listed by referencing the title, author, date and source agency.

Appendix E: Prediction of Effects of the Environment on the Project over the Lifecycle of the Nuclear Facility

A comprehensive site evaluation includes a demonstration of the understanding of the effects of credible site-specific and regional natural and human-induced external events that could affect site operations for each phase of the facility lifecycle.

The largest effects during the project lifecycle are expected to occur during the site preparation and construction stages. Project activities resulting in large and certain environmental effects during site preparation and construction include land re-contouring and water-body infill work.

Early planning ensures that natural and human-induced external events are considered when evaluating environmental effects on health and safety and on security mitigation measures.

Information on external events shall be provided to determine, for the entire lifecycle of the project, that:

- the predicted effects of external events onsite events and the subsequent analyses of environmental effects are credible
- the facility design and the design of site infrastructure are adequate
- the licensee will ensure adequate provisions for the protection of the environment, the health and safety of persons, and national security

E.1 General considerations

All design-basis parameters arising from consideration of natural and human-induced external events shall be identified, and their design basis values justified. These “site-related” parameters influence the design basis values for the nuclear facility and are an important input to the design and overall safety case.

The process used for each type of event analysis shall be consistent with the overall management system.

Limitations presented by data used in the study shall be clearly documented for future use.

For each of the following sections, any parameters having an influence on the design of the facility (design basis parameters) shall be identified, and their design basis values given and justified. All design basis parameters and their values arising from siting considerations shall be documented.

For the licence to prepare site application, where multiple technologies are being considered, the plant design parameters for each of the technologies being considered for the facility shall be provided, so as to demonstrate that each of the technologies is capable of withstanding the design basis conditions attributed to siting considerations.

Guidance

The analysis of postulated events should address combinations of events that are credible for the site and its surrounding region, and may have a larger cumulative effect than the events in isolation.

Some examples of design basis parameters are maximum/minimum air temperatures, maximum snow load, maximum seismic ground motion, extreme flood, maximum tornado wind speeds, and maximum loadings arising from events on nearby transportation routes.

E.2 Potential change of the climate and environment

The applicant shall document the detailed steps and procedures used for assessing the effects of climate change on the site.

Guidance

For more information, see *Incorporating climate change considerations in environmental assessment: general guidance for practitioners* [71].

Effects predictions should have sufficient detail for follow-up verification (for example, quantitative expression of change, such as percent loss; degree of confidence in prediction [related to type of evidence]; roles of mitigation, detailed compensation and performance monitoring; and a rationale for the importance of the follow-up and mitigation provisions.)

Effects predictions should include:

- temperature, humidity, evaporation, high winds, abrasive dust and storms, precipitation, and lightning
- water levels and temperature changes of open water bodies (lakes, bays, and oceans), river floods and droughts (flow rates)
- groundwater level, flow pattern and velocity change resulting from changes of surface water recharge and evaporation
- earthquakes and landslides, and so on, due to changing sea and lake levels and melting glaciers

Effects predictions should pay additional attention to potential environmental effects on the water systems of the project, due to:

- ice from water bodies (lake or river ice) or frazil ice in forebay
- suspended silt
- bio-fouling due to biofilms, attached algae, mussels, fish

Effects predictions should consider the effects of climate and environmental change on populations of non-human biota that could adversely alter predicted environmental effects due to site activities or introduce new potential environmental effects. The mitigation plans for prevention or reduction of plant intake fouling should take into account projected effects of climate change, including frazil ice and bio-fouling (mussels, algae, marine plants).

Future meteorological conditions (that is, accounting for climate change) and the extent of thermal plume from modelling should be used as a basis for extrapolating the long-term ice conditions / silt / fish / mussel / algae density observations for source water body and future potential for effects on the project. Experience with similar operating facilities, such as thermal and nuclear power plants using the same or a similar source water body, should also be considered.

E.3 Prediction of meteorological events

Guidance

The application should document a systematic approach for identifying meteorological events for the site and surrounding region (natural external events). This approach includes steps for continued data collection for meteorological events over the project's lifecycle, such as information that shows that the representative data series is complete, of adequate quality and all sources are identified for verification.

The application should document the verification of the appropriateness, limitations and rationale of the statistical distributions for the data sets.

E.4 Design-basis flood

Guidance

For more information, see:
- IAEA SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15]
- NUREG/CR-7046, PNNL-20091, *Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America* [16]

E.5 Water supply adequacy

Guidance

The application should describe the approach for identifying water supply adequacy for the site and surrounding region. This approach should include the steps for continued data collection over the project's lifecycle.

Water supply adequacy studies should consider:
- reliability and availability of water supply (considering existing water-taking projects in the region, and the potential for additional water-taking projects that could exist in the region)
- water supply changes from naturally induced failures of offsite structures, such as dams, flood control dykes
- if groundwater is used as the water supply: groundwater levels, flow patterns, pumping rates, water quality and the effects on water quality during flooding or drought events (for example, excess minerals released into groundwater during flood events)

For more information, see SSG-18, *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [15].

E.6 Prediction of groundwater, geotechnical, seismic and surface faulting events

The application shall document the investigation and evaluation of the site's and surrounding areas' susceptibility to the following events over the project's lifecycle, and shall address:
- groundwater related events (groundwater flow and contaminant transport)
- geotechnical events
- seismic and surface faulting events

Guidance

The application should provide information on the effects of:
- groundwater conditions:
  - groundwater flow patterns, rates and groundwater level influence the risk of seismic events, and the stability of slopes and foundations
  - the adverse effects of groundwater conditions on site preparation should be evaluated by combining the groundwater conditions with the geotechnical analysis
- geotechnical events:
  - slope instability
  - underground collapse and/or rock fall
  - subsidence or uplift of the site surface
  - instability of the soil foundation due to static or dynamic loads

- geotechnical events on future site activities by combining qualitative explanations with the results of quantitative analyses
- seismic events and surface faulting events:
  - surface faults and lineaments in the regional, local and site scales are identified
  - the potential for these faults to be seismogenic and seismotectonic should be evaluated
  - their effects on future site activities should be assessed
  - mine-induced seismic events, where applicable, and their effects on the structures, systems and components (SSCs)
  - liquefiable soil units should be identified, and their effects on structures and site preparation should be assessed

For more information, see:
- CSA N289.2, *Ground motion determination for seismic qualification of nuclear power plants* [19]
- CSA N289.3, *Design procedures for seismic qualification of nuclear power plants* [62]
- NS-G-3.6, *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants* [14]
- *Dam Safety Guidelines 2007 (2013 Edition)* [72]

E.7 Prediction of non-malevolent biological events

The applicant shall use a systematic process for characterizing and prioritizing risks of external biological events over the project's lifecycle, with emphasis on the facility's operational phase. This process requires a well characterized biological baseline to allow for the prediction of the effects of biological hazards for the project (episodic events and ongoing hazards) and testing mitigation performance.

Analyses shall characterize potential biological phenomena that could affect facility SSCs, such as:
- plant matter, mussels or fish impingement events (for example, smelt runs) that could block water intakes
- bird species, insects or other fauna that may nest near or in air intakes (which could result in blockages of air intakes and pathogens or chemically reactive agents from nesting areas entering air systems)
- moulds, organisms or pathogens, either naturally present or generated by site activities (for example, cooling tower mist or algae in cooling water ponds), which could chemically react with SSCs and may result in reduced reliability of systems if not mitigated in design (for example, lichens chemically attacking concrete), and affect human health, either on- or offsite
- algae or micro-organisms in thermal plume of the facility outlet that could degrade the quality of water entering intakes for drinking and personal hygiene or affect plant intake water quality
- wildlife that could potentially reside within the facility structures and systems and cause damage or long-term degradation

Guidance

Mitigation strategies to counter postulated biological events should demonstrate an effort to minimize effects on the environment and the health and safety of workers and the public.

If any credible biological events are postulated, a description of a follow-up monitoring plan should be documented. The plans should include methods to test the performance of mitigation of those biological hazards.

E.8 Prediction of non-malevolent external fire and explosion events

Non-malevolent external fire and explosion events occur outside the boundaries of the site, but have the potential to have a credible effect on site operations or the execution of emergency plans.

The examination of postulated accidents and malfunctions events and their mitigating strategies shall address:

- the effects of postulated non-malevolent external fire and explosion events for each phase of site development
- environmental effects
- site security program
- site and regional emergency plans for the project
- history of significant non-malevolent external fire and explosion events in the region surrounding the site
- fire and explosion risks that may develop from changes in land use around the site (for example, industrial growth)
- the effects of climate change that may increase the risks or effects of postulated fire events (for example, increased wind speed, drier weather conditions, increased lightning)
- effects on the ability to maintain effective site security during and following these events
- effects on the health and safety of workers and the public, where these events interact with activities performed under the licence (for example, if the event causes a secondary fire in a chemical storage area, which causes an explosion or release of combustion products)
- emergency response requirements posed by these types of events (for example, fire response, chemical spill-control and response)

Guidance

The examination should also address:

- external fire criteria contained NS-G-1.5, *External Events Excluding Earthquakes in the Design of Nuclear Power Plants* [13]
- where applicable, criteria contained in:
  - CSA N293, *Fire protection for nuclear power plants* [73]
  - NFPA 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas* [74]
  - NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting* [75]
  - NFPA 1143, *Standard for Wildland Fire Management* [76]
  - NFPA 1144, *Standard for Reducing Structure Ignition Hazards from Wildland Fire* [77]

E.9 Prediction of external malevolent events

These events originate outside the boundaries of the site but have the potential to have a credible effect on site operations or the execution of emergency plans. Licensee documents related to this topic are considered prescribed information under the NSCA.

Guidance

For more information:

- see appendix D, about the site selection threat and risk assessment (SSTRA) report
- regarding the proposed format of the SSTRA report, the applicant's security organization should contact the CNSC's Directorate of Security and Safeguards at: cnsc.info.ccsn@cnsc-ccsn.gc.ca.

Appendix F: Assessment of Non-Malevolent Accidents and Malfunctions, and of the Consequences

The applicant shall demonstrate that the facility is capable of safely operating within the constraints of the proposed site. Environmental effects shall be as low as reasonably achievable over the full lifecycle of the proposed facility, while taking mitigating measures into account.

Any design information provided by the applicant shall be credible and sufficient to adequately bound the evaluations of environmental effects and site evaluation.

Regardless of the approach used with regards to applying facility design information to their site selection case, the applicant shall demonstrate a clear understanding of the basis from which the safety case is developed.

F.1 Considerations specific to the licence to prepare site

F.1.1 Decision-making considerations

Decisions by the Commission on an application for a licence to prepare site under the *Nuclear Safety and Control Act* (NSCA) for a nuclear reactor project may be made with high-level facility design information from a range of reactor designs without specifying the technology to be constructed.

The applicant shall provide sufficient information to describe the plant-site interface and take into consideration the characteristics of the proposed site. A combination of site characteristics and bounding design parameters will be the focus for comparison with the design characteristics of the actual plant selected for the application for a licence to construct.

If the applicant chooses to pursue a licence to prepare site without choosing a final technology for the site, the activities permitted under the issued licence to prepare site will be limited to site preparation activities that are independent of any specific reactor technology (for example, clearing and grading the site, building site support infrastructure such as roads, site power, water and sewer services).

F.1.2 Considerations that will carry forward to an application for a licence to construct

The design that is eventually selected for construction need not be specifically referenced in the application for a licence to prepare a site, but the design shall fit within the bounding envelope in the approved environmental assessment (EA) and licensing process. The evaluation of the design would be performed once a reactor technology is selected. This evaluation will be required to be demonstrated as part of an application for a licence to construct, or for an amended licence to prepare site, where the applicant wishes to carry out activities such as excavation to bedrock for the plant foot print, or excavation of cooling water intake and outlet tunnels (note that concrete pour will not be permitted under a licence to prepare site).

The less facility design information that is provided in regulatory review processes for a licence to prepare site, the greater the burden will be on the construction licence review process.

An underpinning concept of the bounding approach is that the environmental effects of the reactor design eventually selected for construction should be less than the bounding effects assessed in the application for a licence to prepare site. Similarly, if the site is deemed suitable to host nuclear units using bounding

parameters, then the site should also be suitable for any reactor design that falls within the accepted bounding envelope.

F.1.3 Criteria for level of design detail for an application for a licence to prepare site

At the application phase for a licence to construct (or for an amended site preparation licence, as described above), the applicant shall submit detailed design information to verify that the evaluations presented previously remain valid.

Information required to support site evaluation around the assessment of accidents and malfunctions for the licence to prepare site includes:

- a technical outline of the facility layout
- qualitative descriptions (or technical outline) of all major structures, systems and components (SSCs) that could significantly influence the course or consequences of principal types of accidents and malfunctions
- qualitative descriptions (or technical outline) of the functionality of the SSCs important to safety
- qualitative descriptions of principal types of accidents and malfunctions to identify limiting credible sequences that include external hazards (natural and human-induced), design-basis accidents and beyond-design-basis accidents (severe accidents)

For site evaluation carried out in support of licensing (including emergency planning purposes), the applicant shall address severe accident sequences. The severe accident sequences include, where applicable, simultaneous multiple unit events, with loss of grid/station blackout events, and events with a simultaneous loss of offsite power with loss of normal access to the ultimate heat sink for an extended period of time. Considerations shall also include radioactive sources such as the wet storage bay (also called irradiated fuel bay or spent fuel pool).

The applicant shall provide a description of out-of-core criticality events showing that these events would not violate criteria established by international standards and national guidance as a trigger for a temporary public evacuation.

The applicant shall demonstrate that the safety goals and functional requirements are met.

Guidance

In situations where the technology to be used onsite has either not been selected (subject to a technology selection process that will occur either during or beyond site preparation) or the technology being considered is a first of a kind in Canada (design not yet fully developed), detailed quantified information about accidents and malfunctions characteristics may not be fully established. As a result, the CNSC will accept qualitative information in support of the site selection case with the understanding that there will be an increased level of regulatory scrutiny during the construction and operation licensing processes to validate the claims made.

The applicant should demonstrate that safety goals and functional requirements are met through a high-level safety analysis that demonstrates that the behaviour of the reactors being proposed is understood, and that their consequences can be accurately predicted.

For more information on safety goals, see:

- appendix F.2.2 of this regulatory document
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6] (included in the facility licence where applicable)

F.2 Considerations applicable to all licensing phases

The applicant's site evaluation information shall describe possible malfunctions or accidents associated with the project, the probability of occurrence, and the potential adverse environmental effects of any event sequence that may result in hazardous substance releases or large releases of energy (such as steam or electrical arcs) over the facility's lifecycle and the set of corresponding bounding plant parameters that will form the design basis.

The applicant shall address severe accident sequences. These sequences include, where applicable, simultaneous multiple-unit events, with loss of grid / station blackout events, and events with a simultaneous loss of offsite power with loss of normal access to the ultimate heat sink for an extended period of time. Considerations shall also include radioactive sources such as the wet storage bay (also called irradiated fuel bay or spent fuel pool).

Guidance

The applicant should provide information on future phases, to demonstrate that site evaluation is being maintained with a long-term view.

F.2.1 Assessment of non-malevolent conventional accidents and malfunctions events

Conventional accidents and malfunctions are potential events that result in the release of non-radiological hazardous substances or large releases of energy.

For the facility's technology to be constructed and operated on the site, the applicant shall provide documentation to demonstrate that the safety goals and functional requirements established for non-malevolent conventional accidents and malfunction events are met through safety analysis, showing that the behaviour of the design is understood and that consequences can be accurately predicted.

Guidance

The applicant should consider the following items in the establishment and maintenance of the bounding site and facility parameters:

- past (in the context of existing facilities adjacent to the selected site) and potential abnormal plant operations, accidents and spills of relevance
- malfunction and accident events that have a reasonable probability of occurring during the project's life, and that may involve the release of non-radiological hazardous substances or large release of energy that could significantly affect the environment
- the source, quantity, mechanism, rate, form and characteristics, spatial and temporal extent of above-background levels of contaminants and other materials (physical, chemical, and so on) likely to be released to the surrounding environment during the postulated malfunctions and accidents
- the effects of contaminant releases from conventional accidents and malfunctions on human health and the environment
- mitigation means and measures, including policy, procedures and plans to mitigate, prepare for, respond to, and recover from emergencies from accidents and malfunctions (including emergency response and preparedness)
- contingency, clean-up or remediation work in the surrounding environment (including long-term monitoring) during or immediately following, the postulated malfunction or accident
- measures and provisions, to protect against the postulated accidents and malfunctions
- accident and severe accident management policy and procedures

- supporting infrastructure information external to the site and the exclusion zone; this information should show that emergency response within and external to the site will be sustainable for the facility's lifecycle

F.2.2 Assessment of non-malevolent nuclear accidents and malfunctions

The information considered shall be in line with level of plant design information available at each licensing phase while considering later licensing risks. The CNSC will consider application of a graded approach to safety analysis and facility design in certain areas where the applicant can demonstrate that risk is low for the facility type being considered.

Identification and classification of accidents

Continuing site evaluation shall include consideration of unplanned events involving the reactor which challenge the performance of the safety functions and lead to radiological releases and releases of hazardous substances to the environment.

The applicant's information shall identify and describe the principal types of accidents in the categories described below including the rationales for selecting these sequences as representative accidents.

Events involving the nuclear reactor are classified as follows:
- anticipated operational occurrences
- design-basis accidents
- beyond-design-basis accidents, including severe accidents

For site evaluation carried out in support of licensing (including emergency planning purposes), the applicant shall address severe accident sequences.

Calculation of accident consequences

The applicant shall assess the representative accident sequences in these categories of accidents to determine releases of fission products and the potential releases of nuclear and hazardous substances from the facility.

For anticipated operational occurrences and for design basis accidents, the applicant's information shall demonstrate that designs would be capable of meeting the dose limits specified in REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6].

The applicant shall document the potential offsite releases of radioactive products from representative severe accident sequences.

The applicant shall describe:
- the source term (for example, list of radionuclides, magnitude and timing of the release)
- a description of the process followed to arrive at the final list of radionuclides
- where applicable, a justification of the basis for screening out radionuclides that are not included.

Meeting safety goals

The applicant shall consider quantitative safety goals to ensure that the individual and societal risks to life and health posed by the facility to the public living nearby shall be comparable or less than the risks of viable competing technologies, and shall not significantly add to other societal risks.

The applicant's information shall demonstrate that the design is capable of meeting safety goals.

Guidance

The applicant should describe the results and insights from analyses regarding the representative accident sequences used to define the safety goals.

Two safety goals are defined to protect the environment and the health and safety of the public:

- small release frequency:
  - addresses releases of radioactive material that would trigger temporary evacuation of the population within a few kilometres of the plant to prevent unacceptable health effects resulting from limited reactor core damage with impaired containment
  - the sum of frequencies of all event sequences that may lead to a release that could trigger temporary evacuation shall be less than 1:100,000 per reactor year
- Large release frequency:
  - addresses releases of radioactive material that could require long-term relocation of the public to prevent unacceptable health effects resulting from severe reactor core damage and containment failure
  - the sum of frequencies of all event sequences that may lead to a release that could require long-term relocation of the public shall be less than 1:1,000,000 per reactor year

F.2.3 Prediction of non-malevolent radiological accidents and malfunctions occurring outside the reactor core and out-of-core nuclear criticality safety

The information considered shall be in line with the level of plant design information available at each licensing phase while considering later licensing risks. The CNSC will consider application of a graded approach to safety analysis and facility design in certain areas where the applicant can demonstrate that risk is low for the facility type being considered.

Identification of the source, quantity, form and characteristics of nuclear and hazardous substances

To support the site evaluation case around the discussion of non-malevolent radiological accidents and malfunctions occurring outside the reactor core and out-of-core nuclear criticality safety, the applicant shall provide a documented description of all major systems, other than the reactor, that contain nuclear and hazardous substances that could be released in the environment in significant quantities during an accident at or near the reactor facility. The description shall include the quantity, form and characteristics of nuclear and hazardous substances that could be released.

In some cases, separate facilities on the site may be available that will support the reactor facility (for example, wet storage bay, fresh fuel storage, nuclear waste handling and storage facilities). For each of these facilities, accurate records of inventory shall describe the types and quantities of nuclear and hazardous substances to be contained in the facilities.

Guidance

The applicant should also identify the radioactive sources where direct radiation may be an environmental hazard in accident conditions.

Identification of accidents and malfunctions

The applicant shall characterize unplanned occurrences not involving the reactor and that may lead to releases of nuclear and hazardous substances to the environment. This characterization process includes accidents with sufficiently low frequency leading to public evacuation or relocation.

The characterization process shall identify and describe the principal types of accident and their frequencies, and the rationales for selecting these sequences as representative.

For site evaluation carried out in support of licensing (including emergency planning purposes), the applicant shall address severe accident sequences.

Calculation of releases to the environment

The applicant shall assess the representative accident sequences in these categories of accidents to determine the potential releases of nuclear and hazardous substances from the facility. The assessment shall describe:

- the radiological source terms, including the limiting source terms (for example, list of radionuclides, magnitude and timing of the release)
- the process followed to arrive to the final list of radionuclides
- where applicable, a justification of the basis for screening out radionuclides that were not included

The applicant shall demonstrate that the accident frequencies are well below the frequency limit of:

- 10^{-5} for the small release frequency safety goal for evacuation
- 10^{-6} for the large release frequency safety goal for relocation

Additional characterization information regarding out-of-core criticality safety

The applicant shall describe out-of-core criticality events, taking into account mitigation measures. Requirements for nuclear criticality safety are described inREGDOC-2.4.3, *Nuclear Criticality Safety* [78].

Guidance

The applicant should consider the criteria in the following documents as triggers for a temporary public evacuation and relocation:

- REGDOC-2.4.3, *Nuclear Criticality Safety* [78]
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, Version 2 [10]
- CSA N1600, *General requirements for nuclear emergency management programs* [42]
- *Canadian Guidelines for Intervention During a Nuclear Emergency* [79]
- IAEA GS-R-2, *Preparedness and Response for a Nuclear or Radiological Emergency* [43]

F.2.4 Prediction of accidents and malfunctions events due to malevolent acts

The applicant shall consider the information in line with the level of facility design information available at each licensing phase while considering later licensing risks.

Certain information for this area may be considered to be prescribed information, as per section 21 of the *General Nuclear Safety and Control Regulations*, and require an increased level of information security and protection.

The applicant shall use a systematic process to identify, assess and screen postulated malevolent acts and their consequential event sequences. The applicant shall describe site-specific design-basis threats and beyond-design-basis threats, along with the appropriate safety goals and functional requirements that will be met.

Guidance

In establishing and maintaining the bounding site and facility parameters, the applicant should address:

- while intentional malevolent acts are not accidents, environmental effects resulting from malevolent acts should be compared with the effects identified for conventional and radiological accidents and malfunctions
- site-related information contained in the site selection threat and risk assessment (SSTRA) report that may have a bearing on the events
- events that may involve radioactive or nuclear material in and out of the core
- events that may involve quantities of hazardous substances, with the potential to create significant environmental effects
- events that may involve the large release of energy, with the potential to create significant environmental effects

For each of the event sequences postulated, the applicant should consider:

- source, quantity, mechanism, rate, form and characteristics of contaminants and other materials (physical, chemical and radioactive) likely to be released to the surrounding environment during the postulated event
- mitigation means and measures, including the applicant's policy, processes, procedures and plans to mitigate, prepare for, respond to, and recover from emergencies for malevolent act event sequences (including security needs)
- contingency, clean-up or restoration work in the surrounding environment that would be required during, or immediately following, the postulated malevolent initiated event sequence
- measures, provisions and safeguards to protect against the postulated malevolent act event sequence
- event or accident management policy and procedures for design basis events
- beyond-design-basis malevolent initiated event sequences
- supporting infrastructure external to the site (exclusion zone)

This process may use the consequence analysis of non-malevolent events used in the assessment of the effects of the site activities on the environment.

Identification and classification of accidents

The applicant should identify and classify malevolent acts resulting in accidents in consideration of:

- conventional accidents and spills
- fires and explosions
- internally and externally generated missiles
- human error
- human manipulation of SSCs
- equipment failure or malfunction
- failure of pressurized components or cylinders
- airplane crash
- transportation initiated or related events
- release or dispersion of radioactive or nuclear material
- flooding

Calculation of accident consequences

The applicant shall calculate releases of nuclear or hazardous substances for a limited number of events representative of bounding or limiting credible accidents and malfunctions of malevolent origin. The applicant shall perform consequence analyses as part of demonstrating that safety goals are met.

Appendix G: Effects of the Project on the Environment

G.1 General considerations

The applicant shall provide adequate and sufficient information on the environmental effects of the project so that it can be determined, for the entire lifecycle of the project, whether:

- siting option choices were made to avoid or reduce environmental effects
- the facility design and site infrastructure designs are adequate to meet regulatory requirements (including the exclusion zone boundary, where appropriate)
- the applicant will ensure adequate provision to protect health, safety, security and the environment

Assumptions used in the prediction of the project's effects on the environment over the project lifecycle shall include information about facility operations under normal conditions, and during accidents and malfunctions.

Nuclear and hazardous wastes that will be generated over the nuclear facility's lifecycle shall be described in the predictions of effects on the environment (for example, the location, inventory and disposal of used nuclear fuel are considered).

The applicant shall document the evaluation of the proposed approach for environmental effects monitoring for the current licensing phase, including projected minimum detectable critical effect size, and the confidence associated with the design of the monitoring and baseline data.

Guidance

The goal of monitoring is to generate information for informed decision-making on whether the applicant will make adequate provisions for the protection of the environment for activities being conducted under the current licence.

Provision for environmental protection should be based, in part, on criteria and recommendations that are relevant to the current licensed activities, such as those from the *Environmental codes of practice for steam electric power generation: construction phase* [80]. For example, for activities being conducted under a licence to prepare site, information should include appropriate environmental protection practices in site surface preparation activities, and plans for environmental inspections, for performance verification monitoring for predicted effects, and for mitigation.

Effects predictions and statistical approaches should be documented and used (for example, random sampling wherever feasible) for testing these effects predictions according to published protocols. Effects predictions for pulse exposures (for example spills, accidental or intended releases, silt and storm water runoff events) should be developed appropriately, because they have different requirements than predictions for continuous exposures.

G.2 Effects of the project on air quality

The applicant shall document the evaluation of the proposed approach for environmental effects monitoring for the current licensing phase, including projected minimum detectable critical effect size, and the confidence associated with the design of the monitoring and baseline data.

Guidance

The goal of monitoring is to generate information for informed decision-making on the likelihood and significance of adverse effects from activities being conducted under the current licence.

The applicant should:

- characterize the effects of emissions of nuclear and hazardous substances from the project to the atmosphere during normal operations and during postulated accident and malfunction scenarios
- assess the potential effects of atmospheric nuclear and hazardous substance emission to air quality for each phase of the project, and the ability of the described mitigation measures in eliminating or minimizing any adverse effects

Air quality assessments should include, as applicable:

- information on project-related emission sources from stationary and mobile sources
- information on point source emissions
- information on proposed pollution-control technologies, including environmental effects; the information should be prepared with an awareness of pollution-control technologies available in the industry
- analysis of:
  - the facility's air emissions, using emission estimates that are "conservative" (reasonably expected to exceed the actual emission rates) or with an accurate emissions scenario that assumes operating conditions resulting in the highest concentrations at offsite receptors
  - emission rates and the duration of elevated rates of emission during plausible accident or malfunctions scenarios
- anticipated frequency and duration of warm and cold start-ups and present emissions of key pollutants under these start-up and any other lower-efficiency scenarios
- descriptions of appropriate atmospheric dispersion modelling, to predict effects at the project exclusion zone boundary, fence line and offsite
- models and techniques that are consistent with guidelines such as:
  - *Air Dispersion Modelling Guideline for Ontario* [81]
  - relevant modelling guidance published by the U.S. Environmental Protection Agency
- standard dispersion modelling results, including maximum offsite 1-hour and 24-hour concentrations (for comparison with applicable standards and objectives), frequency analysis for any offsite dispersion that has exceeded limits, and maps of dispersion modelling results
- description of the cumulative effect of emissions from the facility and regional air emissions or air quality
- comparison of air-quality assessment results against applicable provincial and federal air-quality criteria and objectives, such as 24-hour, 3-hour and 1-hour maximum acceptable concentrations (precise guidance can be obtained from provincial regulations and standards)
- where applicable:
  - potential trans-boundary air quality effects
  - effects on Indigenous peoples' lands

Proposed air quality mitigation strategies should include measures to reduce emissions or formation of dust and particles from construction activities and vehicles, and to minimize air emissions from the project during the construction phase, so as to prevent undue effects on surface water quality and any sensitive biological (including human) receptors downwind. For more information, see *Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities* [82].

G.3 Effects of the project on the terrestrial environment

The applicant shall examine and document the effects of the proposed project on the terrestrial environment, including flora and fauna, including effects on wildlife corridors, protected areas, and other valued components (VCs). This assessment includes potential effects from project activities during site preparation, construction, operation, decommissioning and abandonment at the site, at both local and regional scales.

The applicant shall assess the effects from the project on the terrestrial environment in a manner consistent with CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7].

The applicant shall identify species and habitats that will be considered important ecological resources for the site, vicinity, transmission corridors, and other related areas for evaluation of any potential effects.

Guidance

The assessment of project effects on the terrestrial environment should include:

- concentration of contaminants in soil
- concentration of contaminants in the food chain
- characterization of effects on potential terrestrial VCs
- effects of loss of habitat and disturbance on flora and fauna
- effects of physical barriers, including disruption of migration corridors, on wildlife
- effects of disruption, blockage, impediment and sensory disturbance on wildlife
- mortality, direct and indirect, of terrestrial wildlife
- reduction in wildlife productivity and population attributes
- effects prediction using quantitative ecological risk assessment modelling
- effects on biodiversity
- identification of potential credible mitigation measures for all project phases to minimize or eliminate the effects of the project on the proposed terrestrial VCs

Effects predictions:

- provide a quantitative expression of change (for example, percent loss)
- state a degree of confidence in the prediction of habitat loss (related to type of evidence)
- describe the roles of mitigation, habitat compensation and performance monitoring
- provide a rationale for significance and mitigation follow-up
- include a discussion of any uncertainties or limitation of the assessment
- specify predicted effects as the difference in attribute(s) between a future condition without the project, and a future with the project:
    - a future condition without the project has a present condition trajectory into the future, and takes into account any future changes in baseline factors
    - a future with the project has a present trajectory plus the incremental effect of the project

The degree of detail provided in the assessment of the effects should be commensurate with the magnitude of the potential effects.

Sufficient data should be provided for the assessment of anticipated effects during the period of site preparation, facility construction, facility operations and decommissioning. Effect descriptions should include direct and indirect exposure effects that could be used for the environmental effects monitoring and risk assessment purposes.

Information and data on the terrestrial effects should be evaluated against reliable criteria and objectives, so as to ensure that the information can identify likely interactions between the project and its effects on the terrestrial environment's biological components. Guidance on selecting appropriate toxicological benchmarks is provided in CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7].

For more information, see:

- CCME, *A Framework for Ecological Risk Assessment: General Guidance* [83]
- CCME, *A Framework for Ecological Risk Assessment: Technical Appendices* [84]
- *A framework for ecological risk assessment at contaminated sites in Canada: review and recommendations* [85]
- *Priority Substances List Assessment Report. Releases of radionuclides from nuclear facilities (impact on non-human biota)* [86]
- where applicable, provincial guidelines and the following CSA Group standards:
  - N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
  - N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]
  - N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [37]

G.4 Effects of nuclear and hazardous substances on the terrestrial environment

The applicant shall specify uncertainties included in the data (for example, natural randomness, insufficient knowledge, and sampling or measurement error).

Guidance

The typical variation in concentrations of nuclear and hazardous substances at reference site(s) should clearly demonstrate no anthropogenic point source influences. The reference site(s) should closely match the site of interest with respect to the geological, hydrological, meteorological, climate, human and environmental settings (for example, as described in CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]).

The applicant should address relevant federal and provincial guidelines and include, for all cumulative project effects above baseline data:

- detailed maps showing the proposed locations of sampling/monitoring stations for all measurements of nuclear and hazardous environmental concentrations
- an inventory of natural and anthropogenic sources for nuclear and hazardous substances at the site and within local and regional study areas, including predicted/estimated concentrations of nuclear and hazardous substances from the project
- relevant pathways of exposure to nuclear and hazardous substances for terrestrial biota, including parameter values used to predict/calculate the environmental concentrations of nuclear and hazardous substances or exposure for terrestrial VC receptors
- predicted/estimated radiation doses and contaminant exposure to terrestrial VC receptors from the project, including the criteria and benchmarks used in the evaluation of effects associated with nuclear and hazardous substances in the terrestrial environment
- assessment of possible effects from potential changes in the terrestrial environment, due to predicted concentrations of nuclear and hazardous substances and predicted cumulative effects
- identification of potential credible mitigation measures for all project phases to minimize or eliminate the effects of the project on the proposed terrestrial VC receptors

G.5 Effects of the project on the aquatic environment

The applicant shall address the effects from project activities on the aquatic environment, including aquatic habitat and associated aquatic biota.

Guidance

The applicant should address the following general areas:

- the following aquatic habitats (using the parameters of habitat quality, quantity and frequency of use):
  - pelagic (open water)
  - littoral (near-shore and shallow)
  - benthic (bottom-associated)
  - riparian (shoreline)
  - wetland
  - onsite pond and streams that provide habitat for aquatic biota
- the existing physically altered or contaminated habitats that were changed by past operations where there is an existing facility (for example, thermal discharge channels, thermal plumes and past/present physical disruption/structures in near-shore uplands, shoreline/riparian and water bodies)
- habitat of aquatic finfish, shellfish and aquatic plants, excluding aquatic mammals, water birds, waterfowl and reptiles (within the scope of effects of the project on the terrestrial environment)
- maps (including digital databases such as a geographic information system) that show the relationship of the site to major hydrological systems that could affect or be affected by plant construction or operation

With effects predictions, the site evaluation:

- provides a quantitative expression of change (for example, percent loss)
- states a degree of confidence in the prediction of habitat loss (related to type of evidence)
- describes the roles of mitigation, habitat compensation and performance monitoring
- provides a rationale for significance and mitigation follow-up
- includes a discussion of any uncertainties or limitations of the assessment
- specifies predicted effects as the difference in attribute(s) between a future condition without the project, and a future with the project:
  - a future condition without the project has a present condition trajectory into the future, and takes into account any future changes in baseline factors
  - a future with the project has a present trajectory plus the incremental effect of the project

Pre-project or baseline aquatic habitat classification and mapping are precursors to any decisions associated with aquatic habitat loss. Assessing the potential for habitat loss should include:

- numerical statements on the size, frequency, duration and magnitude of change of the affected area and/or volume of habitat, and an assessment of how critical and unique the affected habitat is to biota exploiting the habitat (quantity and quality)
  Note: This information should be supported by maps showing:
  - areas of project activities
  - overlap with aquatic VC habitat in time and space (including VC home range and migration and dispersal estimates)
- descriptions of any project effects that are physical, biological, chemical or radiological in space and time on the habitat, and occurrence of interacting organisms
- descriptions of disturbances of land, shoreline and water bodies from activities in project phases, with:

  - linkages to any expected change in aquatic habitat (for example, offshore placement of excavated material, placement of intake and discharge structures, cofferdams or shoreworks or shoreline protection)
  - an assessment of the water column volume and area affected by the intake water withdrawal
- descriptions of past habitat loss and possible future habitat loss, to set the context for the evaluation of the importance of the possible future losses
- justification if the benthic invertebrate community is not used as indicator of loss of fish habitat (because this is the food base for many fish species)

Submissions should address the *Fisheries Act*. The applicant should review the proposed activities against the requirements of the *Fisheries Act*, because an authorization may be required if an activity is likely to cause serious harm to fish. The applicant should consult the Fisheries and Oceans Canada (DFO) Projects Near Water website for further guidance on self-assessing serious harm to fish and the authorization application process. Depending on the location of the activity (within the proposed licence boundary or outside), the application would be submitted for review to the CNSC or DFO, respectively.

The applicant should evaluate information and data on the aquatic effects against credible criteria and objectives, to ensure that the information is sufficient to identify likely interactions between the project and its effects on the biological components of the aquatic environment. For more information on determining the appropriate aquatic effects criteria and objectives, see:

- CCME, *A Framework for Ecological Risk Assessment: General Guidance* [83]
- CCME, *A Framework for Ecological Risk Assessment: Technical Appendices* [84]
- *A framework for ecological risk assessment at contaminated sites in Canada: review and recommendations* [85]
- *Priority Substances List Assessment Report. Releases of radionuclides from nuclear facilities (impact on non-human biota)* [86]
- where applicable, provincial guidelines and the following CSA Group standards:
  - N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
  - N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]
  - N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [37]

G.5.1 Effects of liquid effluent on the aquatic environment

The applicant shall address the following areas of concern:

- identification of all plant-related structures or alterations of the natural topography that lead to aquatic contaminant inputs to receiving water bodies, floodplains or wetlands at the site
- known (historical and present) aquatic contaminants found at the site and within the local and regional study areas, potentially affecting or affected by plant construction and operation
- confirmation that the information contains sufficient linkage of hydrological mappings to known (historical and present) data and predicted future changes in aquatic contaminant concentrations

Guidance

The applicant should provide sufficient data for the assessment of anticipated effects during the period of site preparation, facility construction, facility operations and decommissioning within, upstream and downstream of the zone of influence of the intake and discharge structures.

Information should follow collective lines of evidence approaches that are recognized by provincial and federal government agencies; for example:

- *Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario* [87]
- EPA-540-R-05-012, *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* [88]

The approach should project the effects on individual biota to those of the population. Information should be supported by peer-reviewed published scientific literature, and be based on a combination of water and sediment chemistry, benthic invertebrate and fish field surveys (accounting for the most sensitive VCs), laboratory toxicity tests and computer modelling. The approach should confirm whether there are or will be significant adverse effects on the aquatic community.

Measurements and data development programs should demonstrate accepted and established and published aquatic contaminant sampling and modelling protocols and field study designs.

Predicted changes to surface water and sediment quality from modelling data should be evaluated using criteria that ensure that surface water and/or sediment quality changes and liquid effluent input into water bodies do not pose risks to human health and the environment. When determining appropriate surface water quality criteria and objectives, the applicant should consider federal guidelines, such as the *Canadian Environmental Quality Guidelines* [65], as well as provincial guidelines and standards, and use water-quality benchmarks from reputable scientific literature.

The description of zones of influence of stressors in space and time should be relative to habitat and occurrence of interacting organisms, specified and supportable from site studies and/or scientific/agency publications dealing with pulse-type and continuous release aquatic effects.

Descriptions of effects should include direct exposure effects (for example, on survival, growth, reproduction, age, species distribution of community), and indirect effects (for example, altered predators, prey, competition, exposure via the food chain).

To determine the dilution factors and to perform mixing zone calculations, it is expected that a conservative final exposure concentration of contaminants in the liquid effluents entering water bodies will be used in accordance with the *Canadian Environmental Quality Guidelines* [65].

G.5.2 Effects of blasting and excavating on aquatic biota

Guidance

Information for this area should be commensurate with the level of blasting and excavating to be performed under each licence phase of the project.

Activities should be planned to avoid critical fish habitat use times and locations within the zone of influence.

The site evaluation should address:

- criteria contained in *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* [89]
- Environment and Climate Change Canada's total suspended solids and turbidity criteria
- control/effect testing for site preparation blasting effects on aquatic biota in nearby site ditches, streams or ponds within the zone of influence
- habitat disruption (for example, through siltation or propagation of sound pressure waves) or physical disruption (for example, disrupting groundwater flows to streams during spawning periods)

- estimates of individual losses of aquatic fauna provided in the context of population attributes (for example, spatial distribution, abundance or density)

The site evaluation should demonstrate that the site preparation and construction activity monitoring plan design is sufficient to define the magnitude, temporal and spatial extent of the source terms and effects (for example, spatial extent of lake bottom affected, numbers of fish killed or injured per blast extrapolated to whole period of activity, effects on benthic invertebrates)

G.5.3 Effects of impingement and entrainment on aquatic biota

The applicant shall address the following, for each project phase:

- site evaluation from the perspective of project-related intake impingement and entrainment effects on aquatic organisms (with an emphasis on VCs); however, total losses of all species should be considered, in order to ensure adequate provision for the protection of the environment
- effects for all consumable and cooling water system options
- defensible and testable predictions of residual adverse effects of water intakes (such as cooling water intakes) on aquatic biota, so that the significance of all effects of the project, and the cumulative effects of other projects, can be assessed
- monitoring programs for entrainment and impingement should be based on peer-reviewed published standards, for example:
  - *Impingement Abundance Monitoring Technical Support Document* [90]
  - *Entrainment Abundance Monitoring Technical Support Document* [91]
- screenings of VCs for susceptibility to intake withdrawal based on susceptibility factors
- descriptions of conceptual model, linking source terms for entrainment and impingement to measures, and predictions of effect

Guidance

Impingement effects occur when large aquatic organisms, such as adult and juvenile fish, aquatic birds, amphibians and aquatic mammals within the source water, are drawn into plant consumable water systems (such as condenser cooling water). These organisms are also trapped against intake debris screens. The resulting impingement catch is usually automatically washed from the intake screens and conveyed to debris bins for disposal as waste. The mortality rate is 100 percent for juvenile fish. The mortality rate is the same for adult fish, unless there is a system for adult live handling and return to the water body.

Entrainment effects occur when small organisms (such as fish eggs, larvae, invertebrates and plankton) within the source water pass through the intake screens, are transported through the consumable water system, and are discharged at the system outlet back into the source water body (or nearby cooling pond). These organisms are exposed to chemical, mechanical (impact) and thermal stresses during entrainment. Mortality rates vary from 25 percent to 100 percent, depending upon the type of organism and species.

The estimates of intake losses (cropping rates) for all life stages of aquatic biota in numbers and biomass should be extrapolated to the whole year, with confidence intervals based upon industry-accepted methods of sampling and analysis. This extrapolation includes the conversion of immature stages to age-1 adult equivalents for estimates of losses of population-level importance (for example, *Defining and Assessing Adverse Environmental Impact from Power Plant Impingement and Entrainment of Aquatic Organisms* [92]). Standard modelling and statistical approaches and contextual methods from government agencies and peer-reviewed published scientific literature should be used to project the effects on individual biota to those of the year-class or population. Mortality is assumed to be 100 percent from impingement, unless a fish handling and return system is included. The effectiveness predictions also vary

by species and life stage. For example, alewife are fragile and easily killed, whereas sucker and eels are not; juveniles are easily injured and do not easily withstand mechanical handling systems.

G.5.4 Effects of thermal plume on the aquatic environment

The site evaluation shall address:

- clear pictorial descriptions showing the locations of discharge structures and areas of influence (temperature, discharge jet) relative to intakes and known/suspected areas of VC-focused habitat use (spawning, rearing, nursery, feeding, wintering areas) and features (for example, substrates, bathymetry, wetlands, aquatic plants)
- descriptions of models (physical, mathematical, conceptual) used to predict temperature effects and thermal discharge jet effects, and to account for long-term effects of climate warming relative to incremental effects of the project
- a listing of aquatic fish and shellfish species, aquatic plants, and invertebrates, identifying which life stages are susceptible to exposure to the interaction, and which subset of species are most sensitive
- descriptions of zones of influence of thermal plume temperature effect (greater than 1ºC above ambient) and physical discharge jet effect with maps and plots (for example, delta above ambient versus distance alongshore and offshore and incremental effect on existing thermal plumes)
- descriptions of alongshore currents, including direction, speed and sediment transport and how these are changed by discharge plumes (deflection, distance and entrainment time for passively drifting biota, such as eggs, larvae)
- direct consequences to the ecosystem (process, structure, function), fish and fish habitat, other aquatic VCs , and indirect effects (via food chain) to aquatic birds and mammals
- descriptions of worst-case and average conditions of discharge water effects, including:
  - the effects of thermal plume on aquatic habitat temporal and spatial changes (for example, discharge jet interruption of ambient lake currents, scouring, temperature changes, sedimentation and particle size, algal cover)
  - consideration of risk to aquatic biota from “pulse” temperature increases and decreases relative to ambient changes such as thermal shock from ongoing operations, outages and anticipated operational occurrences
- temperature predictions (mean, median, maximum and minimum) during critical life stage periods for potential VCs and plots of hourly maxima showing duration at peak temperatures
- effects of contaminants released in the thermal discharge, including the combined effects of temperature and contaminants, as well as the potential for gas-bubble disease
- effects on fish, including:
  - physical displacement of life stages exposed to discharge jets
  - lethal and sub-lethal effects
  - behavioural responses (attraction and avoidance) for all life stages
  - direct effects (survival, growth, reproduction, diet, condition) and indirect effects (for example, discharge angling mortality, increased larval mortality from predation due to physical transfer out of discharge channel to open water body, disease prevalence) analysis and evaluation of the incremental effects from the project, and the cumulative effects of combined discharges
- the monitoring and sampling methodologies that will be used onsite along with descriptions of sampling/monitoring points and equipment

When considering the use of a nearby large body of water as the ultimate heat sink for heat rejection (for example, using once-through condenser cooling water), the applicant shall predict, monitor and document the effects of the resultant thermal plume and the physical effects of the discharge water flow on nearby bodies of water. This analysis shall consider the potential effects of using cooling towers on air quality, terrestrial and aquatic environment.

Guidance

The scope of information should be scaled to the scope of anticipated adverse effects. For example, a once-through cooling system (diffuser) would require complex analysis but cooling towers would not.

When using a cooling pond that is separate from the body of water, the applicant should consider the interactions between the cooling pond and the nearby bodies of water and should mitigate any potential effects of cooling pond containment dike breaches.

G.6 Effects of the project on hydrogeology

The site evaluation shall address effects from project activities on hydrogeology.

Guidance

Information should:

- address the prediction and monitoring of effects of activities on:
  - flow patterns and rates of groundwater flow
  - physical, chemical, and biological characteristics of the groundwater within the site, local and regional areas, during site preparation, construction, operation, decommissioning or abandonment of the facility
- describe how the hydrogeological investigations program is being conducted to permit the assessment of the effects of features and processes from the baseline hydrogeology and groundwater quality information contained in the licensing submissions
- include the physical, chemical, and biological water-quality parameters, rates, flow patterns of groundwater flow and movements of released contaminants through local and regional groundwater flow systems
- provide sufficient information to enable the reader to become familiar with the physiographic, hydrologic, hydrogeological and groundwater uses at the site and in its vicinity

Investigations of groundwater, as well as the investigation and modelling of dispersion and retention of radionuclides in groundwater should demonstrate consideration of the criteria contained in NS-G-3.2, *Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants* [8].

Well-supported effects predictions should be provided (for example, quantitative expression of change and a rationale provided for significance and mitigation follow-up). For more information, see *Operational Policy Statement: Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* [93].

The applicant should assess and document the potential radiological doses and exposures to hazardous substances to persons, including mitigation strategies, for each phase of the facility's lifecycle.

G.7 Effects of the project on human health

The applicant shall address the following effects on the health and safety of persons:

- onsite during normal operations, and during accidents and malfunctions
- offsite during normal operations, and during accidents and malfunctions
- for each area of concern itemized, identify and characterize appropriate human receptors

Key components of the assessment process include the identification of:
- potential project-human interactions
- radiological and non-radiological (that is, nuclear and hazardous substances) contaminants of potential concern (COPCs)
- human receptors and assessment criteria

Guidance

Normal operations include unplanned exposures and upset conditions that do not cause an emergency to be declared.

Receptor exposure characteristics (for example, inhalation or ingestion rates), when used, should be referenced from accepted Canadian or international sources, for example:
- for hazardous substances, *2013 Canadian Exposure Factors Handbook* [94]
- the most up-to-date International Commission on Radiological Protection (ICRP) references
- the U.S. Environmental Protection Agency's Agency for Toxic Substances and Disease Registry

For information on protection of workers from hazardous chemicals, see American Conference of Governmental Industrial Hygienists. The reason for selecting an alternate source of receptor characteristics should be given, with the source/citation clearly documented and accompanied by justified assumptions. A conservative approach should be used in assessments of project effects on human health.

The effects documented for accidents and malfunctions should correlate with the postulated accidents and malfunctions scenarios.

G.7.1 Radiological risks

The applicant shall describe and document the method used to estimate effective and equivalent doses.

Guidance

Documentation should identify radiation doses received by persons on and offsite at similar existing facilities (when they exist) that use the best available technology economically achievable (BATEA). This benchmarking exercise should be used to develop a licensing basis that achieves similar or lower doses.

These estimates may be based on modelling of prospective radionuclide exposure (both external exposure and, internal exposure via intakes of radionuclides) to the identified human receptors using methods and/or dose coefficient acceptable to the CNSC, for example, as described in:
- CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [36]
- ICRP 68, *Dose Coefficients for Intakes of Radionuclides by Workers* [95]
- ICRP 72, *Age-dependent Doses to the Members of the Public from Intake of Radionuclides – Part 5, Compilation of Ingestion and Inhalation Coefficients* [96]
- U.S. EPA, Federal Guidance Report No. 12: *External Exposure to Radionuclides in Air, Water, and Soil* [97]

For direct exposure to radiation from photon-emitting sources, methods based on Monte Carlo techniques and point kernel codes may also be used

Information provided to verify the reference dose data should be demonstrated to be reliable and associated with workplace and work activities that represent the proposed facility-related workplace and work activities.

The basis for assumptions regarding exposure duration and exposure frequency should be documented.

Calculated doses to persons, both on and offsite, should be traceable to the input data (for example, receptor exposure characteristics, relevant radiological data). Sample dose calculations should be included that demonstrate the link from input data (such as concentrations of radionuclides in air) to dose to persons, with all relevant assumptions provided.

G.7.2 Mitigation strategies

The applicant shall ensure that mitigation strategies reflect preventive principles and are technically and economically feasible. Emphasis shall be placed on eliminating or minimizing hazards through design and engineered controls.

The applicant shall ensure that engineered controls demonstrate that the controls reduce the magnitude of each radiation source and keep radiological exposures of workers as low as reasonably achievable (ALARA) during routine and non-routine work practices (for example, operating and maintenance activities). The radiological design objectives for these engineered controls shall be specified.

The applicant shall identify administrative controls that will be used to minimize doses to workers. The applicant shall describe contingency responses in the event of failed engineered and administrative controls.

The applicant shall demonstrate that the assessment of the significance of effects resulting from the project takes into account the implementation of the proposed mitigation measures. The assessment results shall demonstrate that the predicted effective and equivalent doses to workers and members of the public will be ALARA and below the applicable radiation dose limits specified in sections 13 and 14 of the *Radiation Protection Regulations*. The criteria for determining whether significant adverse effects to workers onsite, resulting from the accidents and malfunctions associated with the reactor facility, for each phase of the project are presented in section 15 of the *Radiation Protection Regulations*. The applicant shall describe all necessary measures that will be taken to evacuate any persons from site who are not involved in the control of the emergency situation. When the emergency has ended, and the recovery phase has begun, the dose limits in sections 13 and 14 of the *Radiation Protection Regulations* will apply.

Guidance

The applicant should credibly demonstrate that the design meets the dose acceptance criteria and safety goals defined in REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* [6].

Doses to workers from routine and non-routine work practices should be estimated, including the maximum annual effective and equivalent doses to categories of workers.

Where prevention of effects cannot be assured, the applicant should describe administrative mitigation controls such as personal protective equipment, training and procedures. Only mitigation measures that are technically and economically feasible (ALARA and BATEA) should be considered.

G.7.3 Hazardous substances

Guidance

The applicant should identify and describe:

- the methods used to estimate exposure, via various pathways, of the various human receptors to hazardous substances

- the engineering controls to be applied to reduce the magnitude of each source

When estimating the significance of the effects resulting from the project, the applicant should account for the implementation of the proposed mitigation measures. The assessment results should demonstrate that the estimated exposure to hazardous substances of persons onsite during the normal operation will not exceed criteria specified by Health Canada, the CCME or other agencies acceptable to the CNSC.

For more information, see reference material available from;
- U.S. Environmental Protection Agency (U.S. EPA)
- World Health Organization (WHO)
- Organization for Economic Cooperation and Development (OECD)

G.8 Prediction of non-human biota dose

The applicant shall address non-human biota radiation dose assessment methods used to quantify effects for releases of nuclear substances. The scope shall include analysis of both the effects of chronic and acute exposures on terrestrial and aquatic organisms.

G.8.1 Exposure information

The applicant shall perform explicit calculation of radiation doses to non-human biota with recognized approaches and software tools.

Guidance

The applicant should provide a high-level discussion of the relative merits of alternative approaches to put the presented approach in a current national and international context.

An example of an acceptable approach is available in CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7]. The applicant should document the details of transfer parameters and their validation for site conditions. Site-specific data, and/or authoritative data sources, should support model structure and parameter choices. The applicant should note the choice of food chain transfer factors for VCs, which can vary by orders of magnitude in different environments for different species.

The applicant may use a software tool, if it addresses risks to VCs explicitly or by reasonable analogy. If an approach different from CSA N288.6 [7] is used, the applicant should describe the model structure and implementation. Regardless of the approach taken, the applicant should document a few representative samples of dose calculations starting with media and/or food concentrations.

G.8.2 Selection of radiation benchmarks

For controlled releases, the applicant shall quantify and interpret doses for the effects on life history parameters (morbidity, mortality, reproduction). If numerical benchmarks for chronic radiation effects are exceeded, effects shall be interpreted at multiple levels of organization in an ecological context relative to the potential for effects on individual biota, populations, communities and ecosystems.

The applicant shall describe long-term consequences of accidental releases (for example, as shown from studies of major nuclear accidents such as “Differences in effects of radiation on abundance of animals in Fukushima and Chernobyl”, published in *Ecological Indicators* [98].

Guidance

For accidental releases, the applicant should use the notional range of 1–10 Gy to describe the effects of acute exposure. Comparisons may only be possible for analogous organisms. Consideration should also be given to statistical interpretation of acute exposures.

Because derivation of non-human biota dose benchmarks for generic use is still ongoing, the applicant should reference and describe alternative interpretations of radiation risk. A documented detailed description would be appropriate only if more restrictive criteria could lead to a conclusion of likely and significant adverse effects.

For more information on suitable approaches and their relationships to environmental protection goals, see:

- *Using an Ecosystem Approach to complement protection schemes based on organism-level endpoints*, *Journal of Environmental Radioactivity* [99]
- ICRP 108, *Environmental Protection – the Concept and Use of Reference Animals and Plants* [100]

G.8.3 Uncertainties

Guidance

The applicant should address the effects of using radiation weighting factors suggested in CSA N288.6, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills* [7] for calculating a "biota effective dose" from absorbed dose (for example, weighting factors of 40 for alpha particles, and 3 for tritium beta particles).

Chronic exposures that are less than a "biota effective dose" screening criterion of 10 µGy/h only need minimal interpretation or discussion.

A deterministic modelling approach is acceptable, providing that model structure and parameters are documented, reasonably conservative, and whenever possible, supported by site-specific data.

Some examples of conservative choices are:

- selection of high transfer factor and diet exposure scenarios
- use of dose coefficients that assume all energy is absorbed regardless of body size and geometry
- setting radionuclide concentrations in some non-human biota equal to surrounding media and/or food items
- assuming secular equilibrium for the presence of radioactive daughters, not adjusting for bioavailability for sediment/soil ingestion
- calculating maximum possible doses to critical and sensitive organs (for example, bone marrow) relative to average whole-body doses

The applicant should use a probabilistic modelling approach if there is ambiguity in the validity of dose estimates for site-specific conditions and/or VCs. For example, a probabilistic approach is appropriate when it is necessary to grossly extrapolate information for other areas or species, or when there is ambiguity in the protection of any threatened or endangered species, or species of concern.

Glossary

For definitions of terms used in this document, see REGDOC-3.6, *Glossary of CNSC Terminology*, which includes terms and definitions used in the *Nuclear Safety and Control Act* (NSCA) and the regulations made under it, and in CNSC regulatory documents and other publications. REGDOC-3.6 is provided for reference and information.

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Additional Information

The following documents are not referenced in this regulatory document but contain information that may be useful to the reader:

- Canadian Council of Ministers of the Environment (CCME), *Canadian National Ambient Air Quality Objectives: Process and Status*, 1999
- Canadian Environmental Assessment Agency (CEAA), *Technical Guidance for Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012*, Ottawa, Canada, 2014
- International Atomic Energy Agency (IAEA), TECDOC-1487, *Advanced nuclear plant design options to cope with external events*, Vienna, Austria, 2006
- United States Environmental Protection Agency (U.S. EPA), Report No. EPA-821-R-02-002, *Case study analysis for the proposed section 316(b) phase II existing facilities rule*; *Chapter 5: Methods used to evaluate I&E*, Washington, DC (USA), 2002

CNSC Regulatory Document Series

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